SWRHL-94r

SUMMARY

Off-Site Radiological Safety and Resident Evacuation Program for Project Rulison (Detonation Phase)

Project Rulison is the second jointly-sponsored government-industry nuclear experiment performed to determine the feasibility of using nuclear explosives to stimulate production and recovery of natural gas from low permeability gas-bearing formations. Although it was extremely unlikely that a venting of radioactive material would occur as a result of the detonation, the Public Health Service (PHS), Southwestern Radiological Health Laboratory (SWRHL), conducted an off-site radiological safety program for the detonation phase of the experiment. In cooperation with the CER Geonuclear Corporation, the PHS also arranged for resident evacuation and other precautions in the area to minimize any possible hazard which might result from ground motion produced by the detonation.

The off-site radiological safety program included operating a system of environmental surveillance networks in the Project Rulison area, and fielding radiation monitoring teams in the off-site area for the detonation. The surveillance networks consisted of a radiation dosimetry network, sampling networks for air, milk, water, and vegetation, and collection of milk cow feed, animal tissue and natural gas samples. The surveillance networks were supplemented on detonation day with monitoring aircraft and ground monitors carrying portable environmental sampling and monitoring equipment.

The basic criteria for off-site radiological protection were those contained in Section II-A of the Appendix to the AEC Manual, Chapter 0524. These are the Radiation Protection Standards for Individuals and Population Groups in Uncontrolled areas, and provide radiation dose standards for external and internal exposure, as follows:

Type of Exposure	Based on Exposure to Individuals	Based on an Average Exposure to a Suitable Population Sample
Whole body gonads or bone marrow	0.5 rem/year	0.17 rem/year
Thyroid or bone	1.5 rem/year	0.5 rem/year

The off-site environmental surveillance program indicated no radioactivity was released to the environment from the detonation. The dosimetry network and air, milk and water sampling networks were operated prior to and following the detonation and showed no changes in environmental radioactivity levels. Aerial monitoring over the test well and ground monitoring in the off-site area with portable radiation survey instruments on the day of the detonation also showed no radioactivity above background levels.

Based on predicted ground motion in the vicinity of the test well as a result of the nuclear explosion, residents within five miles of the test well were evacuated from the area for several hours on D-day during the detonation period, and gas and electrical utilities in the area were disconnected to minimize fire hazards. PHS representatives remained in the area with five families who chose to remain at home.

Arrangements were made for all residents in the area between five and nine miles from the test well to be outdoors and away from structures at detonation time to minimize any possible hazard from falling objects or structural damage. CER Geonuclear Corporation was responsible for arranging to have residents in the town of Grand Valley and the community of Rulison two structure heights from standing objects at detonation time, in cooperation with SWRHL evacuation coordinators stationed at these communities. A uranium and vanadium ore processing mill and two schools, which were beyond the nine-mile radius, were also evacuated.

The resident evacuation program was successfully carried out with no accidents, injuries, or health problems observed by or reported to the PHS prior to or after the Project Rulison detonation.

SWRHL-94r

SUMMARY

Off-Site Radiological Safety and Resident Evacuation Program for Project Rulison (Detonation Phase)

Project Rulison is the second jointly-sponsored government-industry nuclear experiment performed to determine the feasibility of using nuclear explosives to stimulate production and recovery of natural gas from low permeability gas-bearing formations. Although it was extremely unlikely that a venting of radioactive material would occur as a result of the detonation, the Public Health Service (PHS), Southwestern Radiological Health Laboratory (SWRHL), conducted an off-site radiological safety program for the detonation phase of the experiment. In cooperation with the CER Geonuclear Corporation, the PHS also arranged for resident evacuation and other precautions in the area to minimize any possible hazard which might result from ground motion produced by the detonation.

The off-site radiological safety program included operating a system of environmental surveillance networks in the Project Rulison area, and fielding radiation monitoring teams in the off-site area for the detonation. The surveillance networks consisted of a radiation dosimetry network, sampling networks for air, milk, water, and vegetation, and collection of milk cow feed, animal tissue and natural gas samples. The surveillance networks were supplemented on detonation day with monitoring aircraft and ground monitors carrying portable environmental sampling and monitoring equipment.

The basic criteria for off-site radiological protection were those contained in Section II-A of the Appendix to the AEC Manual, Chapter 0524. These are the Radiation Protection Standards for Individuals and Population Groups in Uncontrolled areas, and provide radiation dose standards for external and internal exposure, as follows:

Type of Exposure	Based on Exposure to Individuals	Based on an Average Exposure to a Suitable Population Sample
Whole body gonads or bone marrow	0.5 rem/year	0.17 rem/year
Thyroid or bone	1.5 rem/year	0.5 rem/year

The off-site environmental surveillance program indicated no radioactivity was released to the environment from the detonation. The dosimetry network and air, milk and water sampling networks were operated prior to and following the detonation and showed no changes in environmental radioactivity levels. Aerial monitoring over the test well and ground monitoring in the off-site area with portable radiation survey instruments on the day of the detonation also showed no radioactivity above background levels.

Based on predicted ground motion in the vicinity of the test well as a result of the nuclear explosion, residents within five miles of the test well were evacuated from the area for several hours on D-day during the detonation period, and gas and electrical utilities in the area were disconnected to minimize fire hazards. PHS representatives remained in the area with five families who chose to remain at home.

Arrangements were made for all residents in the area between five and nine miles from the test well to be outdoors and away from structures at detonation time to minimize any possible hazard from falling objects or structural damage. CER Geonuclear Corporation was responsible for arranging to have residents in the town of Grand Valley and the community of Rulison two structure heights from standing objects at detonation time, in cooperation with SWRHL evacuation coordinators stationed at these communities. A uranium and vanadium ore processing mill and two schools, which were beyond the nine-mile radius, were also evacuated.

The resident evacuation program was successfully carried out with no accidents, injuries, or health problems observed by or reported to the PHS prior to or after the Project Rulison detonation.

SWRHL-94r

OFF-SITE RADIOLOGICAL SAFETY AND RESIDENT EVACUATION PROGRAM FOR PROJECT RULISON

(Detonation Phase)

by the
Environmental Surveillance Program
Southwestern Radiological Health Laboratory

U. S. Department of Health, Education and Welfare
Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration
Bureau of Radiological Health

January 1970

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

This surveillance performed under a Memorandum of Understanding (No. SF 54 373) for the U. S. ATOMIC ENERGY COMMISSION

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Report is SWRHL-94r

ABSTRACT

Project Rulison is the second jointly-sponsored government-industry nuclear experiment performed to determine the feasibility of using nuclear explosives to stimulate production and recovery of natural gas from low permeability gas-bearing formations. ~~This report presents~~ the operational procedures and results of the off-site radiological safety and resident evacuation programs conducted for the detonation phase of Project Rulison are presented. ~~the experiment by the Public Health Service (PHS), Southwestern Radiological Health Laboratory (SWRHL).~~

The off-site radiological safety program included operating a system of environmental surveillance networks before and after the detonation, and fielding radiation monitoring teams for the detonation. All surveillance and monitoring results indicated no changes in environmental radioactivity levels following the experiment.

Based on predicted ground motion in the vicinity of the test well as a result of the nuclear explosion, residents within five miles of the test well were evacuated from the area for several hours on D-day during the detonation period, and gas and electrical utilities in the area were

(1 of 2)

disconnected to minimize fire hazards. PHS representatives remained in the area with five families who chose to remain at home. Arrangements were made for all residents in the area between five and nine miles from the test well to be outdoors and away from structures at detonation time to minimize any possible hazard from falling objects or structural damage. All evacuation procedures went smoothly, and no accidents or injuries to residents were reported before or after the detonation.

(cont'd)

(20f2)

TABLE OF CONTENTS

	Page
ABSTRACT	i
LIST OF FIGURES	v
LIST OF TABLES	vi
I. INTRODUCTION	1
II. OPERATIONAL GUIDE	4
A. Responsibilities	4
B. Organization	5
C. Criteria	6
III. OPERATIONAL PROCEDURES	8
A. Population and Milk Cow Surveys	8
B. Medical Activities	10
C. Ground Motion Evacuation	11
D. Monitoring	15
E. Aerial Monitoring	17
F. Veterinarian Activities	18
G. Field Communications	18
IV. ENVIRONMENTAL SURVEILLANCE	20
A. Air Sampling	20
B. Dosimetry	23
C. Milk Sampling	24
D. Water Sampling	25
E. Natural Vegetation Sampling	27
F. Milk Cow Feed Sampling	28
G. Livestock and Wildlife Sampling	29
H. Natural Gas Sampling	29
I. Whole Body Counting	29

Table of Contents (continued)

	Page
V. RESULTS	31
A. Evacuation and Medical Activities	31
B. Radiological Monitoring	34
C. Dosimetry	35
D. Air Sampling	36
E. Water Sampling	37
F. Milk Sampling	38
G. Milk Cow Feed Sampling	39
H. Natural Vegetation Sampling	39
I. Livestock and Wildlife Sampling	40
J. Natural Gas Sampling	40
VI. SUMMARY	41
REFERENCES	42
APPENDIX A. Analytical Procedures - Technical Services - SWRHL	62
APPENDIX B. Water Sampling Results	64
APPENDIX C. Milk Sampling Results	68

LIST OF FIGURES

Figure		Page
1.	Rulison Area Map	43
2.	Rulison Population Summary	44
3.	0-5 Mile Population Distribution	45
4.	Air Sampling Stations	46
5.	Dosimetry Stations	47
6.	Milk Sampling Stations	48
7.	Water Sampling Stations	49
8.	Test Well Vicinity Sampling Stations	50
9.	Natural Vegetation Sampling Locations	51

LIST OF TABLES

Table		Page
1.	TLD Network results.	52
2.	Gross beta results - Rulison Air Surveillance Network.	53
3.	Tritium in atmospheric moisture samples.	54
4.	Water sampling results.	55
5	Milk sampling results.	56
6.	Milk cow feed results.	57
7.	Tritium in natural vegetation (plot samples).	58
8.	Natural vegetation results (station samples).	59
9.	Strontium-89 and -90 in wildlife.	60
10.	Natural gas results.	61

I. INTRODUCTION

Project Rulison is a joint experiment sponsored by Austral Oil Company Incorporated, Houston, Texas, the U. S. Atomic Energy Commission and the Department of the Interior, with the Program Management provided by CER Geonuclear Corporation of Las Vegas, Nevada, under contract to Austral. Its purpose is to study the economic and technical feasibility of using underground nuclear explosions to stimulate production of natural gas from the low productivity, gas bearing Mesaverde formation in the Rulison Field.

The nuclear explosive for Project Rulison was detonated successfully at 3:00 p.m. plus 0.1 seconds Mountain Daylight Time, September 10, 1969, at a depth of 8,425.5 feet below ground level and was completely contained. Preliminary results indicate that the Rulison device behaved about as expected; i.e., with a yield of 40^{+20}_{-} 4 kt. The wellhead of the emplacement well, Hayward 25-95A, is at an elevation of 8,154 feet above mean sea level (MSL) and is located 1,976.31' east of west line and 1,813.19' north of south line of Section 25, Township 7 South, Range 95 west of 6th p.m., Garfield County, Colorado, which corresponds to geodetic coordinates of longitude 107°, 56', 53" West and latitude 39°, 24', 21"N. The general area and site location are shown in Figure 1.

Although it was extremely unlikely that a venting of radioactive material would occur as a result of this detonation, the Public Health Service (PHS), Southwestern Radiological Health Laboratory (SWRHL), conducted an off-site radiological safety and resident evacuation program for the detonation phase of Project Rulison in cooperation with the Colorado Department of Health. This report describes the procedures followed and the information collected in conducting these programs.

The off-site radiological safety program included operating a system of environmental surveillance networks in the Project Rulison area, and fielding radiation monitoring teams in the off-site area for the detonation. The surveillance networks consisted of a radiation dosimetry network, sampling networks for air, milk, water, and vegetation, and collection of animal tissue and natural gas samples. The surveillance networks were supplemented on detonation day with monitoring aircraft and ground monitors carrying portable environmental sampling and monitoring equipment.

Based on predicted ground motion in the vicinity of the test well as a result of the nuclear explosion, the Director of Nuclear Operations requested SWRHL to arrange for resident evacuation and other precautions in the area to minimize any possible hazard which might result

from the ground motion. The evacuation program consisted of evacuating residents and disconnecting power and gas utilities within a five-mile radius of the test well during the test, and arranging for residents in the area between five to nine miles from the test well to be outdoors at a distance of two structure heights from any standing object at the time of detonation. A uranium and vanadium ore processing mill and two schools, which were beyond the nine-mile radius, were also evacuated. CER Geonuclear Corporation was responsible for arranging to have residents in the town of Grand Valley and the community of Rulison two structure heights from standing objects at detonation time, in cooperation with SWRHL evacuation coordinators stationed at these communities. CER was also responsible for the evacuation of operating mines within 42 miles of surface zero.

II. OPERATIONAL GUIDE

A. Responsibilities

The SWRHL serves as the off-site Radiological Safety Organization for the AEC in accordance with the AEC-PHS Memorandum of Understanding, No. SF-54-373, as amended. The off-site areas of responsibility are beyond the boundaries of the Nevada Test Site and other test locations. The Project Rulison off-site area was designated by the Atomic Energy Commission Nevada Operations Office as starting at 600 feet from the Rulison surface ground zero. Accordingly, the SWRHL was responsible for conducting an off-site radiological safety and resident evacuation program for Project Rulison. SWRHL responsibilities included:

1. Documenting the radiological situation in the off-site areas through comprehensive environmental sampling and radiation monitoring.

2. Assuring continuous protection of public health and safety by determining potential and past exposures, and implementing protective measures as directed by the Director of Nuclear Operations.

3. Conducting a public contact program in the off-site areas to assure local residents that all reasonable safeguards were employed to protect public health and property from test effects.

4. Collecting information regarding incidents which may have been attributed to the test program.

B. Organization

The Director, SWRHL, served as the Off-site Radiological Safety Officer, and was responsible for the overall off-site radiological safety and resident evacuation programs for Project Rulison. Program planning and field activities were performed by the SWRHL Environmental Surveillance Program.

Field and support personnel for the operation were provided by the PHS, the Colorado Department of Health, several Colorado county health departments, Utah State Department of Health, and the University of Wyoming. The distribution of participating personnel on detonation day from these organizations was as follows:

Organization	No. of Personnel
Public Health Service	47
Colorado Department of Health	8
Colorado County Health Departments	7

Organization	No. of Personnel
Utah State Division of Health	3
University of Wyoming	4

University of Wyoming personnel were provided through the Wyoming State Department of Public Health.

C. Criteria

The basic criteria for off-site radiological protection were those contained in Section II-A of the Appendix to the AEC Manual, Chapter 0524. These are the Radiation Protection Standards for Individuals and Population Groups in Uncontrolled Areas, and provide radiation dose standards for external and internal exposure, as follows:

Type of Exposure	Based on Exposure to Individuals	Based on an Average Exposure to a Suitable Population Sample
Whole body gonads or bone marrow	0.5 rem/year	0.17 rem/year
Thyroid or bone	1.5 rem/year	0.5 rem/year

Guidance in preparing the operational safety plans for Project Rulison included the following criteria:

> "The off-site rad safe plans for Project Rulison will be based on the assumption that there will be no significant uncontrolled release of radioactivity off of the controlled area. The controlled area will be of such a size and shape that, in the highly unlikely event there is a significant uncontrolled radioactive release, an individual

located at any point beyond the boundary for two hours immediately following the onset of this postulated release would not receive a total radiation dose to the whole body in excess of fifteen rem or a total radiation dose in excess of seventy-five rem to the thyroid from iodine exposure. These criteria are provided solely for the purpose of planning for off-site radiological safety. Their use in this respect is not intended to imply that these numbers constitute acceptable limits for emergency doses to the public under accident conditions. In the unlikely event that there is a significant uncontrol ed radioactive release, every reasonable effort will be made to reduce the exposure. Post event activities for Project Rulison will be conducted under AEC MC 0524, Appendix 0524, Section 1A, Individuals in Controlled Areas, and Section IIA, Individuals and Population Groups in Uncontrolled Areas."(1)

III. OPERATIONAL PROCEDURES

A. Population and Milk Cow Surveys

In February 1969, SWRHL conducted a detailed population and milk cow survey of the area within a twenty-five mile radius of the Project Rulison test well. The survey was designed to identify the location and number of residents and milk cows in the area, as well as to obtain information regarding water supplies, type of milk cow feed, and other pertinent information about each residence. Each rural home in the area was visited by a PHS representative who recorded information on a survey form. General population figures for communities were obtained from various community officials and residents.

The survey information was stored on magnetic tape for computer retrieval, and a population and milk cow directory was prepared. The directory was separated into sections containing information on human population, population with family milk cows, and population with Grade A dairies. The survey information was also used to produce population distribution maps, such as shown in Figure 2.

The Project Rulison area is largely rural in nature. The nearest communities are Rulison at five and one-half miles, and Grand Valley at six and one-half miles from the test well. The rural residents live on small farms or acreages and usually have gardens and orchards. The majority of the residents are employed outside the immediate area. Approximately one-fourth of the residents operate ranches as their primary source of income.

In addition to the detailed survey to 25 miles, a review of census data was conducted for a sector between 0 and 180 degrees from the test well, from 25 to 150 miles from ground zero. Information was collected on community populations and Grade A dairy herd distribution through the sector.

The information collected during the population and milk cow surveys was used to plan the environmental surveillance and evacuation programs for Project Rulison. Environmental surveillance networks were designed to reflect the geographical coverage according to the distribution of people and dairy cows. Evacuation procedures were planned for pre-shot evacuations associated with ground motion predictions as well as for emergency evacuations in case of a venting of radioactive material.

In addition to the survey of the permanent population, an investigation of the transient population to be expected in the Rulison area during the detonation period was conducted in February and updated in July 1969. Hunting seasons and periods of livestock grazing and tourist traffic were investigated.

B. Medical Activities

Safety measures recommended by the AEC to minimize possible hazards associated with predicted ground motion from the nuclear detonation included (1) evacuation of persons from the area within five miles of the test well, and (2) evacuation of all buildings within the area from five to nine miles to a distance of two structure heights from standing objects at detonation time. To be certain that all residents in these areas were physically able to follow these recommendations, an evaluation of medical patients in the area was conducted.

Surveys to identify medical patients and handicapped residents in the rural area within nine miles of ground zero were conducted during April and again in July of 1969 by SWRHL. CER Geonuclear Corporation personnel were responsible for similar surveys in the communities of Grand Valley and Rulison in August.

During August, the SWRHL medical officer visited 40 invalids and handicapped residents to make a medical evaluation and determine what special facilities might be required to protect their health and welfare during the evacuation period.

Thirteen practicing physicians in Grand Junction, Rifle, and Glenwood Springs were contacted to discuss specific cases and solicit support for any emergencies arising during Project Rulison activities. Administrators of three hospitals in Rifle and Grand Junction were contacted and arrangements made to utilize all three facilities in the event of emergencies. The physicians decided it was necessary to hospitalize one chronically ill patient and thought it was advisable to allow a second patient already hospitalized to remain in the hospital through D-day. The PHS physician recommended that the first patient be hospitalized two days early for convenience.

C. Ground Motion Evacuation

Ground motion evacuation personnel arrived in the Project Rulison area several days prior to the scheduled detonation date to familiarize themselves with the rural homes and the residents to be evacuated. These personnel were divided into teams, with each team responsible for evacuation of residences in a specific area. Residents were

contacted by the team member responsible for their evacuation, and the evacuation plan was explained to the resident. Residents were subsequently visited daily by the PHS representatives to keep them informed of the Project schedule and activities.

Evacuation agreement forms were used to arrange evacuation of residents from the area within five miles of the test well. The evacuation agreements provided for Austral Oil Company to reimburse each householder at a given rate per adult per 24-hour period of evacuation, and a lower rate per family member twelve years of age or under. One-fourth of the per diem rate was allowed for each 6-hour period, or fraction thereof, away from home. Residents at five locations chose not to evacuate. Figure 3 shows the location of each household within the five-mile radius area, and indicates the number of adults and children residing in each household.

Residents between five and nine miles from the test well had the option of either evacuating the area or standing outside and away from buildings, power lines, and similar structures at the time of the detonation.

If evacuation of invalids had become necessary, the operation would have been arranged and supervised by a PHS medical officer. On D-day the PHS medical officer was present in the area for this purpose and to administer medical attention to residents if an emergency arose.

On D-day, roadblocks were established at H-4 hours at the five-mile area perimeter to assure that no unauthorized persons entered the evacuation area until persons who were evacuated had returned to their homes. Roadblocks were coordinated by PHS personnel and established by members of the Sheriff's posse. Evacuation teams were then responsible for assuring that the residents within five miles of ground zero were evacuated or that a PHS representative was with persons who chose not to evacuate, and that their utilities were disconnected by H-2 hours.

The disconnection of gas and electrical service at evacuated homes was recommended by the AEC to minimize the remote possibility of fire or other damage that might result from gas line or wiring damage associated with the ground motion. The utility disconnections were coordinated by CER Geonuclear Corporation and carried out by utility personnel under contract with Austral Oil Company. PHS personnel provided liaison for the effort.

Arrangements were made with groups of residents of the five-to nine-mile area to meet the respective evacuation teams at convenient predesignated locations at H-60 minutes. Each team was responsible for determining that all residents of the area were present at the meeting location or otherwise out of their houses, and for reporting the information to the control point by radio. Each group stood by at the assigned location with the evacuation team until after detonation.

Two PHS personnel also assisted CER Geonuclear Corporation and local officials in making arrangements to have residents in the communities of Grand Valley and Rulison clear of structures at detonation time. On D-day, this action was reported to the control point by radio when completed.

Schools at Grand Valley, Rifle, Rulison and Collbran were dismissed prior to the detonation so students could reach home before H-hour. Confirmation that students had been released from school was reported to the control point by a PHS representative in contact with school administrators.

The Union Carbide uranium-vanadium mill near Rifle, Colorado, was partially evacuated fifteen minutes before H-hour, through

coordination with a PHS representative standing by at the mill. The U. S. Bureau of Mines complex at Anvil Points was evacuated one hour before H-hour, and the fact was reported by a PHS representative to the control point.

D. Monitoring

Radiation monitors were dispatched to the Project Rulison area four days before the scheduled detonation date to become familiar with road systems and populated locations, and gain general knowledge of the area. The monitors were equipped with supplies for collecting environmental samples, one or more scintillators to measure low level gamma activity in the background to 3 mR/hr range, a Geiger-Mueller survey instrument (background to 2 R/hr), and a high range ionization chamber rate meter (background to 50 R/hr). Monitors also carried portable gamma rate recorders, portable air samplers, and thermoluminescent dosimeters (TLD's) to supplement the permanent environmental surveillance networks in the off-site area.

Thirteen monitors were assigned to the general areas of Collbran, Silt, and the "Silt-Collbran Cut-Off" road to become familiar with populated locations lying in the proposed downwind sector for

accidentally vented radioactivity. If a release of radioactivity had occurred, these monitors were prepared to contact the residents and coordinate their evacuation from the cloud trajectory if it became necessary. Each monitor was familiar with a group of residences and would have been responsible for evacuating that group and reporting to the control point.

On D-day, monitors were stationed downwind from the test well at H-2 hours. Monitor standby locations were adjusted in accordance with revised cloud trajectory predictions, and at H-hour, six monitors were stationed at the summit of the Silt-Colbran Cut-Off road, eight at the Fairview School in the Silt Mesa area, four at McClure Pass on Colorado State Highway 133, and one at the Ruedi Dam near Basalt. Two monitors were stationed at Grand Junction for dispatch to any downwind area in which they might be needed.

If a venting had occurred, monitors were strategically located to document cloud passage and residual activity levels, and to take appropriate action to prevent unnecessary exposure to residents. Each member of the ground motion evacuation teams also carried radiation survey instruments to provide monitoring support if the need arose.

E. Aerial Monitoring

The PHS aerial monitoring crew arrived in the Project Rulison area three days before the detonation date to become familiarized with the terrain in the Rulison vicinity in preparation for a D-day tracking mission. In addition, several flights over the Battlement Mesa area were made to check for possible hunters, ranchers, or other persons in the wilderness area near the test well.

Two PHS aircraft were airborne near the test well site at H-hour. The first aircraft was equipped to conduct a radioactive cloud tracking and sampling mission with a gross gamma detection system and cloud sampling gear. The second aircraft served as a radio relay station between the control point and PHS field personnel, and as a backup aircraft for cloud tracking and sampling.

The gross gamma detection system in the primary aircraft consisted of a 4- by 4-inch NaI(Tl) crystal detector connected to a single channel analyzer and count-rate meter. Output from the count-rate meter was recorded on a strip-chart recorder mounted in the co-pilot's instrument panel. Cloud sampling apparatus included (1) a sequential air sampler to collect particulate samples across a cloud, (2) a mass air sampler to collect an averaging sample of cloud

particulates and gases utilizing a filter and charcoal bed, (3) an Anderson impactor particulate sampler, (4) a molecular sieve for moisture and CO_2 samples, (5) a "grab bag" sampler for inert gas samples, and (6) an electrostatic precipitator to collect particulates for radiochemical analysis.

F. Veterinarian Activities

Prior to the Project Rulison detonation, approximately 35 veterinarians in western Colorado and the Denver area were contacted by SWRHL and Colorado Department of Health veterinarians. The basic program and schedule for Project Rulison were reviewed for them, and questions regarding possible project effects on livestock and wildlife were answered. A SWRHL veterinarian was dispatched to the Rulison area at D-7 days with a mobile laboratory in preparation for the investigation of any complaints relative to livestock and wildlife following the detonation.

G. Field Communications

A two-way radio network provided communication between the control point, the SWRHL field office in Grand Junction, the SWRHL aircraft, and project vehicles in the Rulison area. SWRHL provided a separate radio relay system in its tracking aircraft for communication with four evacuation teams who were not equipped with the

primary network radios. The SWRHL aircraft also provided an emergency relay service for communications between the control point and field personnel during temporary failure of the primary radio network immediately after the detonation.

IV. ENVIRONMENTAL SURVEILLANCE

Environmental surveillance activities for Project Rulison were conducted prior to the detonation to document the background radiological levels in the off-site environment, and continued after the detonation to monitor any changes in environmental radioactivity. All PHS environmental samples were returned to SWRHL by parcel post or government vehicle for analysis. If it had been indicated, samples could have been returned by PHS aircraft. Analytical procedures and types of analyses for samples are described in Appendix A.

The Colorado Department of Health also established and operated environmental surveillance networks in coordination with the SWRHL program. The results of the Colorado program are reported in a separate document by the Department of Health.

A. Air Sampling

1. Rulison Air Surveillance Network

Stations utilizing the Gelman-Tempest air sampler with a particulate filter and a charcoal cartridge were established

at the populated locations and communities listed below and shown in Figure 4.

DeBeque	Silt	Gunnison
Grand Valley	Glenwood Springs	Paonia
Rulison	Montrose	Bond
Rifle	Carbondale	Vega Reservoir
Mesa	Leadville	Silt Mesa

Beginning at D-3 weeks, 24-hour particulate samples were collected daily through D+2 weeks at all stations, and through D+3 weeks at the first stations listed. Charcoal cartridge samples were collected from D-4 days to D+7 days at all stations, and through D+2 weeks at the first six stations.

2. Air Surveillance Network (ASN)

Air Surveillance Network stations (part of the 103-station permanent SWRHL network in the western states) are located at Durango, Grand Junction, Denver, Rangley and Pueblo, Colorado. All except the Pueblo station were operated on a daily basis in support of Project Rulison. Data from other stations in this network would have been examined if a venting had occurred.

3. Portable Air Sampling

Monitors were equipped with battery powered and propane powered portable air samplers on D-day to supplement the network stations as required. These samplers were equipped to collect particulate and charcoal cartridge samples, and would have been placed at ranches or along roads to intercept a radioactive cloud had venting occurred.

4. Radiation Alert Network

Air sampling results from the national Radiation Alert Network (RAN) operated by the PHS were also available to SWRHL. Field estimates of beta activity on daily particulate samples are reported to PHS headquarters in Maryland, and selected filters are counted and analyzed further by laboratory techniques, if required.

5. Atmospheric Moisture Sampling

Several days prior to the detonation, atmospheric moisture samples were collected by both molecular sieve and "freeze-out" sampling systems at several locations near the Project Rulison test well. These samples were collected to establish a background for tritium in the air environment. Post-event samples will be collected as the evaluation phase of Project Rulison progresses, and separate reports will be prepared on these results.

B. Dosimetry

Eight thermoluminescent dosimeter (TLD) stations were established in an array from 5 to 10 miles from the test well, and twelve TLD stations were established at the following surveillance stations (Figures 5 and 8):

Grand Junction	Mesa
Paonia	Vega Reservoir Area
Carbondale	Silt Mesa area
Glenwood Springs	Silt
Rifle	Grand Valley
DeBeque	Rulison

Each TLD station was equipped with three EG&G TL-12 thermoluminescent CaF_2:Mn dosimeters, which have a sensitivity range from 5 mR to 5000 R when placed in the field for three-week to four-week exposure periods. Background data were collected for three-week and four-week periods in April and August, respectively. The dosimeters were exchanged several days prior to the detonation to monitor any radioactive release and document post-event exposure levels. The TLD network was terminated at D+8 weeks.

Additional TLD's were issued to all personnel participating in the field operation for personal dosimeters, and monitoring team

personnel carried TLD's for issue to off-site residents and for other placement as deemed necessary. Since no radioactive release occurred, none of these TLD's was placed or issued.

C. Milk Sampling

1. Rulison Milk Sampling Stations

A Rulison Milk Sampling Network consisting of the fifteen stations shown in Figure 6 was established in the Rulison area. The sampling stations represented five Grade-A producers, and ten family milk cow stations, as listed below:

*Alex C. Urquhart Dairy, Rifle

*Rock N Pines Dairy, Glenwood Springs

*Glenn Taylor Dairy, Molina (near Collbran)

*C. W. Young Dairy, Collbran

*Rupert W. Wasson Dairy, Mesa

William C. Earley Ranch, Collbran

Arthur Linn Ranch, Collbran

Clifford Hill Ranch, Collbran

Don Burtard Ranch, Rulison

Felix Sefcovic Ranch, Rulison

Billy Lee Smith Ranch, Rulison

Rufus Raley Ranch, Silt

Don Jacket Ranch, Silt

Emil Lopez Ranch, Silt

Mrs. George Currier Ranch, Molina

*Grade-A producer.

Milk samples were collected at D-5 months, D-2 weeks, D+3 days and D+8 weeks. If venting had occurred, sampling would have been continued and expanded as necessary.

2. Stand-by Milk Sampling Stations

SWRHL Stand-by Milk Surveillance stations in Colorado, part of a network covering all states west of the Mississippi River, would have been activated if a venting had occurred. Stand-by stations in Colorado are located at:

Craig	Rocky Ford
Fort Collins	Colorado Springs
Glenwood Springs	Durango
Grand Junction	Monte Vista
Delta	Alamosa
Salida	

D. Water Sampling

The Rulison Water Sampling Network is shown in Figure 7, and consisted of the following water sampling stations:

1. Twelve municipal supplies within 25 miles of surface ground zero plus municipal supplies at Glenwood Springs, Carbondale, Paonia, Cedaredge, and Redstone.

2. Two private wells in the Morrisania Mesa area.

3. Two private wells in the Holmes Mesa area.

4. Two private wells in the Monument Mesa area.

5. Two springs in the Morrisania Mesa area, and two springs in the Holmes Mesa area.

6. Four Reservoirs:

   Vega Reservoir near Collbran.

   Harvey Gap Reservoir, 6 miles north of Silt.

   Beaver Lake on Grand Mesa.

   Jumbo Lake on Grand Mesa.

7. Eight streams:

   Battlement Creek, 1 mile south of Morrisania Community Hall.

   Battlement Creek, at the test well near the USGS gauging station above Morrisania Mesa.

   Plateau Creek, 1 mile south of Collbran.

   Cache Creek, at intersection with Holmes Mesa Road.

   Wallace Creek, at Wallace Creek School.

   Parachute Creek, beneath the bridge in Grand Valley.

Buzzard Creek, 6-1/4 miles east and 1/2 mile north of Collbran.

Mamm Creek at Rifle Airport.

West Divide Creek at Fairview School.

8. A special test well on Battlement Creek near the USGS gauging station above Morrisania Mesa.

Water samples from the network stations were collected at D-5 months, D-2 weeks, and at D+2 months. Assorted samples were also collected from other locations when a request for a radioactivity analysis was made. These usually involved local residents requesting their water supply be sampled for radioactivity content. If a venting had occurred, network stations and other locations would have been sampled on a regular basis as long as deemed necessary.

E. Natural Vegetation Sampling

Vegetation samples were collected in July 1969, from 12 sampling plots in the vicinity of the test well, as shown in Figure 8. Twenty-seven samples from each plot were collected and analyzed to determine the background values for tritium. Perennial species were selected at nine stations in order to sample vegetation that was capable of radionuclide uptake through active transpiration during most

of the year. The species collected included Artemesia tridentata (big sagebrush), Abies lasiocarpa (subalpine fir), and Pseudotsuga menziesii (Douglas fir). The same species could not be collected at each plot due to limited accessibility and limited distribution of the species in the area. Subalpine fir and Douglas fir, though different species, have similar leaf morphology. Alfalfa samples were collected at the other two stations.

Samples of fruit were collected at two locations on Morrisania Mesa and Holmes Mesa. Only Bing cherries were ripe at this time, so samples of these and immature apples, pears, and apricots were collected from orchards in the area.

Sagebrush and native grass samples were also collected for other radionuclide background determinations at D-1 week at the eight TLD stations between five and ten miles from the test well, at six locations along the Silt-Collbran Cut-Off road, and 11 stations between Redstone and Paonia, as shown in Figures 8 and 9.

F. Milk Cow Feed Sampling

Milk cow feed samples were collected from the fifteen milk sampling stations at D-1 week at the same time milk samples were collected. Samples were collected which were representative of the type of

feed being used by lactating animals at the time of collection. Samples consisted of native grass and hay, legume hay, and grass pasture. No post-event feed samples were collected.

G. Livestock and Wildlife Sampling

The Colorado Game and Fish Department and the Western Meat Packers, Inc., assisted in obtaining samples of beef cattle thyroids and thyroid, muscle, abomasum and abomasum contents of deer in the Project Rulison area. Several samples were collected in this manner and were shipped to SWRHL for analysis.

H. Natural Gas Surveillance

Natural gas samples were collected from five gas wells in the vicinity of the Rulison test well to obtain background information, and post-event samples were collected from two wells on D+2 days (Figure 8). Additional post-event samples will be collected from the experimental wellhead and gas wells in the vicinity of the test well as the evaluation phase of Project Rulison progresses. Separate reports will be prepared on these results.

I. Whole Body Counting

The whole body counting facility at SWRHL was available on a 24-hour basis to scan field personnel or residents of the area who may have

been exposed to internal contaminants. If this had been deemed necessary, bio-assay samples from each individual would have been collected and analyzed for radionuclides. The Colorado Department of Health whole body counting facility in Denver was also on stand-by to provide similar support. Since no radioactive venting occurred, neither facility was used for Project Rulison.

V. RESULTS

A. Evacuation and Medical Activities

On detonation day, there were 140 people residing at 42 homes in the area within five miles of the test well. Five households, consisting of 10 persons, chose not to evacuate the area so they could attend to farm duties. PHS representatives were stationed with them at their respective residences on D-day and arranged to have them outdoors at the time of detonation to minimize any possible hazard from ground motion. In addition to the permanent residents, there was one deer hunting camp which was inhabited in the five-mile area. Eighteen hunters, two guides and two camp attendants resided on a temporary basis at this camp, but evacuated to a ranch near Collbran on D-day. With the exception of the 10 residents who remained at their homes, all residents left the area by H-2 hours. All gas and power services were disconnected by H-2 hours.

Beginning at H + 1-1/2 hours, the residents in the five-mile radius area were escorted to their homes by PHS and utility personnel. The utility services were reconnected and a full inspection of each household was made to check for gas leaks and electrical problems.

All residents who had planned on returning home on D-day were home by 2100 hours and their utility services were restored by 2300 hours.

In the area of 5 to 9 miles from the site, residents were outside their homes and two structure heights away from standing objects by H-15 minutes. PHS personnel stood by with these people from H-1 hour through H-hour. After the detonation, these residents returned to their homes and PHS personnel revisited them to assure that all had returned safely and had encountered no problems at their residence as a result of the detonation.

Two PHS personnel also assisted CER Geonuclear Corporation representatives and local officials in making arrangements to have residents in Grand Valley and Rulison clear of structures at detonation time. At H-35 minutes, this action was completed and reported to the control point. These residents began re-entering their homes several minutes after the detonation.

On D-day, the PHS medical officer revisited two residents in Grand Valley who had previously been contacted so their current medical status could be determined. In addition to this, he visited a medical patient in the Rulison area who had not been previously identified. The resident was found to be ill and required assistance in situating

herself comfortably out of doors until after the detonation. A Sheriff's deputy remained with her until after the detonation and assisted her in returning to her house. No other medical problems were encountered.

As planned by school officials, schools at Grand Valley, Rifle and Collbran were dismissed prior to the detonation so the students could return home prior to H-hour. Confirmation of school evacuation was reported to the control point by H-45 minutes by a PHS representative in contact with school administrators.

Partial evacuation of the Union Carbide uranium-vanadium mill near Rifle was carried out in coordination with a PHS representative by H-15 minutes. In addition to the mill, the U. S. Bureau of Mines complex at Anvil Points was evacuated one hour prior to H-hour. The Union Carbide and Anvil Points personnel returned to their work several minutes after the detonation.

On D+1 day, each rural home within nine miles of the test well was visited by the PHS representatives who had evacuated that home to check on problems or questions that may have arisen. All residents returned home safely by D+2 days, and in general, the residents reported that damage to their homes from ground motion was slight

and less than expected. There were no accidents, injuries, or health problems observed by or reported to the PHS prior to or after the Project Rulison detonation.

B. Radiological Monitoring

1. Ground Monitoring

Several days before D-day, monitors collected background gross gamma measurements at various locations in the potential downwind sector with Geiger-Mueller survey instruments. Background levels of 0.01 and 0.02 mR/hr were observed at all locations in the sector.

On D-day, monitors were stationed in the downwind trajectory expected for the existing meteorological conditions. Monitor stand-by locations were adjusted in accordance with current cloud trajectory predictions, and at H-hour six monitors were stationed at the summit on the Silt-Collbran Cut-Off road, eight at the Fairview School in the Silt Mesa area, four at McClure Pass on Colorado State Highway 133, one at the Ruedi Dam near Basalt, and two were in Grand Junction for dispatch to Gunnison or Glenwood Springs, as needed. The monitors remained on station until H+4 hours, and observed only background readings on survey instruments during that period.

2. Aerial Monitoring

Two PHS aircraft were airborne on station near the test site at H-hour. Following the detonation, the primary sampling aircraft conducted low level passes over the test well at H+19 minutes and H+50 minutes. No gamma activity above background levels was detected on either pass, therefore no samples were collected.

After H-hour the second aircraft served as a communication relay system for PHS field personnel when the primary radio network failed temporarily after the detonation. The aircraft remained in the area until H+2 hours. No samples were collected with this aircraft.

C. Dosimetry

Background data collected from the Rulison dosimetry network in April and August had an average value for the whole network of 0.24 mR/day. The network average for the post-event period was 0.29 mR/day. The exposure rates for the two periods are listed in Table 1.

Past experience with TLD background measurements in the PHS Nevada dosimetry network has shown that monthly exposure rates

have an average coefficient of variation of about 60%.[2] Thus, the 20% difference between the pre-event and post-event network averages for the Rulison network is not unusual. Factors contributing to the variation in measured exposure include inherent system error, changes in natural background rates, and the amount of transit time to and from the laboratory compared to the total exposure period.

The TLD's issued to all PHS field personnel also indicated no exposures above background levels during the D-day monitoring activities.

D. Air Sampling

Gross beta results for the particulate filters collected at Rulison Air Surveillance Network stations are summarized in Table 2. There was no significant difference between pre-event and post-event average activity levels. Daily charcoal cartridge samples collected from D-1 week through D+2 weeks were gamma scanned, and contained no radionuclides above the minimum detectable activity (0.1 pCi/m^3 for single isotopes). Gross beta results on daily filters showed no increase above background levels following the detonation.

The pre-event and post-event averages of gross beta activity concentrations were similar to the gross beta concentration ranges measured for the months of August and September by the SWRHL Air Surveillance

Network operated throughout the western United States. The ranges in the monthly average gross beta concentration at all 103 stations were 0.2 to 0.8 pCi/m^3 and 0.2 to 0.4 pCi/m^3 for August and September, respectively. The Rulison network average for all stations was 0.4 pCi/m^3 in August, and 0.3 pCi/m^3 in September.

A series of atmospheric moisture samples was collected in the vicinity of the test well on September 1 and 2 to establish background levels for tritium. All results, except for one sample collected by aircraft over the test well, were below the minimum detectable activity, as shown in Table 3. The minimum detectable activity for standard conditions, i.e., 5 ml of water and a 100-minute count time, is 0.4 pCi/ml. The minimum detectable activity for the samples reported in Table 3 varies because the volume of water collected on several samples was less than 5 ml. All samples were counted for 100 minutes. Post-event atmospheric moisture samples were not collected.

E. Water Sampling

Water sampling results are given in Appendix B and summarized in Table 4. No significant differences in radioactivity levels are apparent between pre-event and post-event samples. Gross alpha and gross beta radioactivity in pre-event water samples was generally

higher than concentrations observed in raw surface waters sampled throughout the nation and analyzed by the Federal Water Pollution Control Administration (FWPCA). The concentration ranges from post-event Rulison samples were similar to the national ranges. The monthly averages from the most current reports [3] were 0 to 49 pCi/l for gross alpha and 2 to 113 pCi/l for gross beta.

F. Milk Sampling

The results of two background milk sampling surveys and two post-event sampling surveys are given in Appendix C and summarized in Table 5. The concentrations of iodine-131, strontium-89, strontium-90, and cesium-137 in these samples were within the ranges in concentrations reported for these same radionuclides by the Pasteurized Milk Network (PMN). This network of approximately 62 stations collects weekly milk samples from selected milksheds representing major milk production and consumption areas throughout the nation. The ranges of the monthly average concentrations for all network stations during the six-month period March through August, 1969, were 5 to 27 pCi/l for strontium-89, 2 to 19 pCi/l for strontium-90, and 10 to 79 pCi/l for cesium-137.[4] All PMN results for iodine-131 were below minimum detectable levels (10 pCi/l), and no analyses for tritium were made.

G. Milk Cow Feed Sampling

Samples of hay and native grasses representative of milk cow feed were collected prior to the event to establish background levels. Small concentrations of zirconium-95 were found in all of these samples by gamma spectral analysis. This was attributed to world-wide fallout and considered as part of the background. Table 6 gives the concentrations of zirconium-95 found in samples from various locations. No post-shot feed samples were collected.

H. Natural Vegetation Sampling

The mean tritium concentrations in natural vegetation and fruit samples collected in the Rulison area in July 1969 are given in Table 7. Gamma scan results for individual samples of sagebrush and native grass collected at 25 stations in the potential downwind sector at D-1 week are given in Table 8. The small amount of zirconium-95 found in these samples was considered due to normal background activity associated with world-wide fallout. No post-event vegetation samples were collected since no release of radio-activity occurred.

I. Livestock and Wildlife Sampling

Beef cattle thyroid samples collected at Grand Junction slaughter houses on D-8 days for background analysis were gamma-scanned, and contained no activity above detectable limits. Six steers were sampled from Carbondale, Silt, and DeBeque, Colorado.

Muscle and thyroid samples from five deer were gamma-scanned for background data. Abomasum tissue and abomasum contents from one of the deer were also gamma-scanned. The deer were killed in late August by hunters or road vehicles. No gamma-emitting nuclides above minimum detectable activities were observed in any of the samples. Strontium-89 and -90 analysis results for the various samples are given in Table 9. No post-event livestock or wildlife samples were collected.

J. Natural Gas Sampling

Analytical results for background and post-event natural gas samples collected from wells in the Rulison area are given in Table 10. The post-event sample from the Section 8 well was not representative of formation gas. The post-event sample from the Federal 28-0 well indicated no change in radon-222 concentrations in the gas following the detonation.

VI. SUMMARY

The SWRHL off-site environmental surveillance program conducted for Project Rulison indicated no radioactivity was released to the environment from the underground nuclear detonation. A dosimetry network and air, milk and water sampling networks operated prior to and following the detonation showed no changes in environmental radioactivity levels. Aerial and ground monitoring with portable radiation survey instruments on the day of the detonation also showed no radioactivity above background levels.

The SWRHL resident evacuation program, conducted to minimize any possible hazard associated with ground motion produced by the detonation, was successfully carried out. The area within five miles of the test well was evacuated (except for five families who remained in the area with PHS representatives), and residents in the area from five to nine miles of the test well moved outdoors during the detonation. There were no accidents, injuries, or health problems observed by or reported to the PHS prior to or after the Project Rulison detonation.

REFERENCES

1. TWX from John S. Kelly, AEC, DPNE, to Robert E. Miller, AEC, NVOO, dated March 17, 1969.

2. Fitzsimmons, C. K., William Horn, Environmental Monitoring with Thermoluminescent Dosimeters. SWRHL-58r (Las Vegas, Nevada: DHEW, PHS, CPEHS, 1969). p. 17.

3. Radiological Health Data and Reports. Public Health Service, Consumer Protection and Environmental Health Service, Dept. of Health, Education and Welfare. Vol. 10, nos. 3, 4, 7, 8 and 9. March, April, July, August and September, 1969.

4. Radiological Health Data and Reports, Public Health Service, Consumer Protection and Environmental Health Service, Dept. of Health, Education and Welfare. Superintendent of Documents, Government Printing Office, Washington D. C. 20402. (referenced milk results are scheduled for publication).

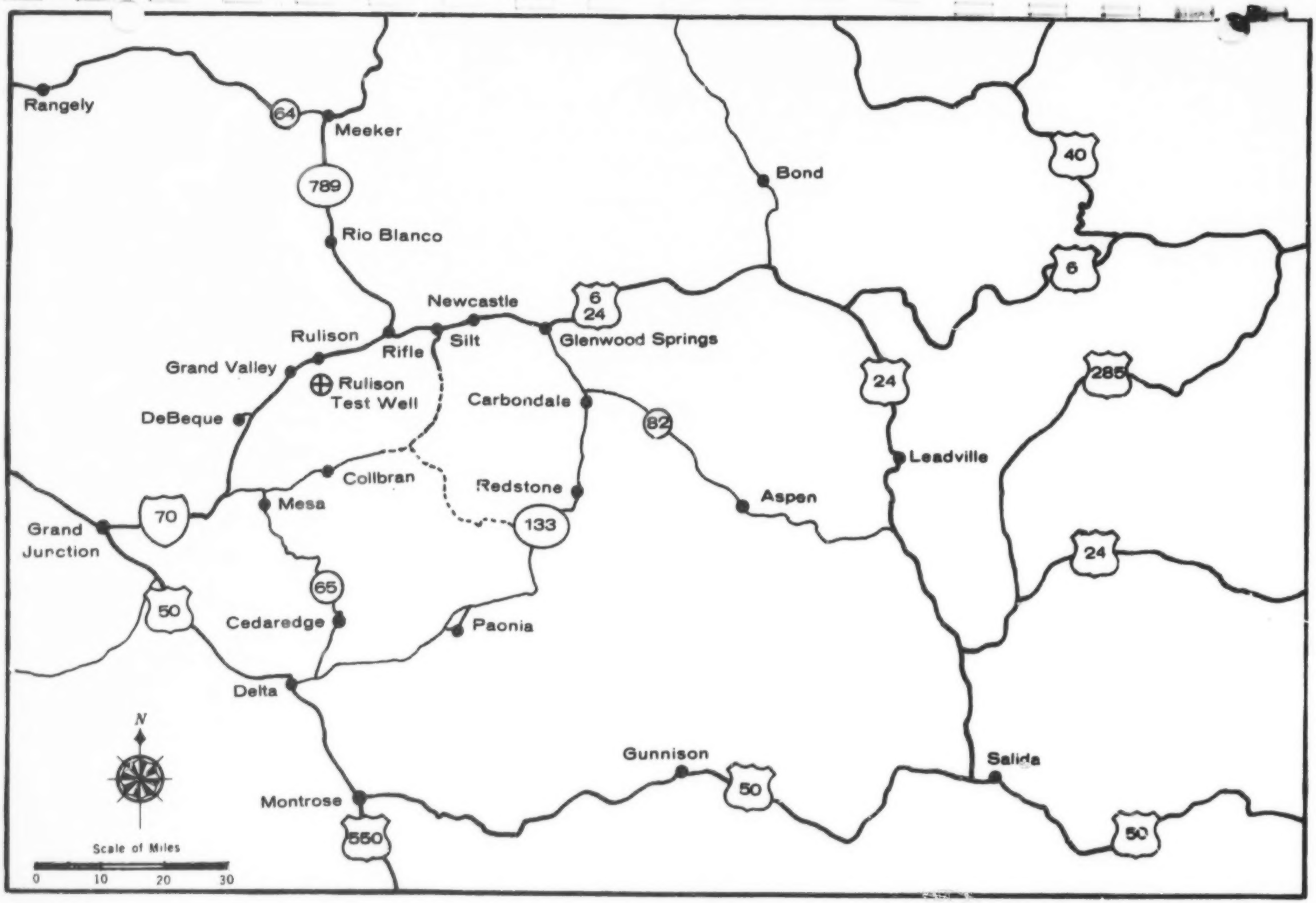

Figure 1. Rulison Area Map

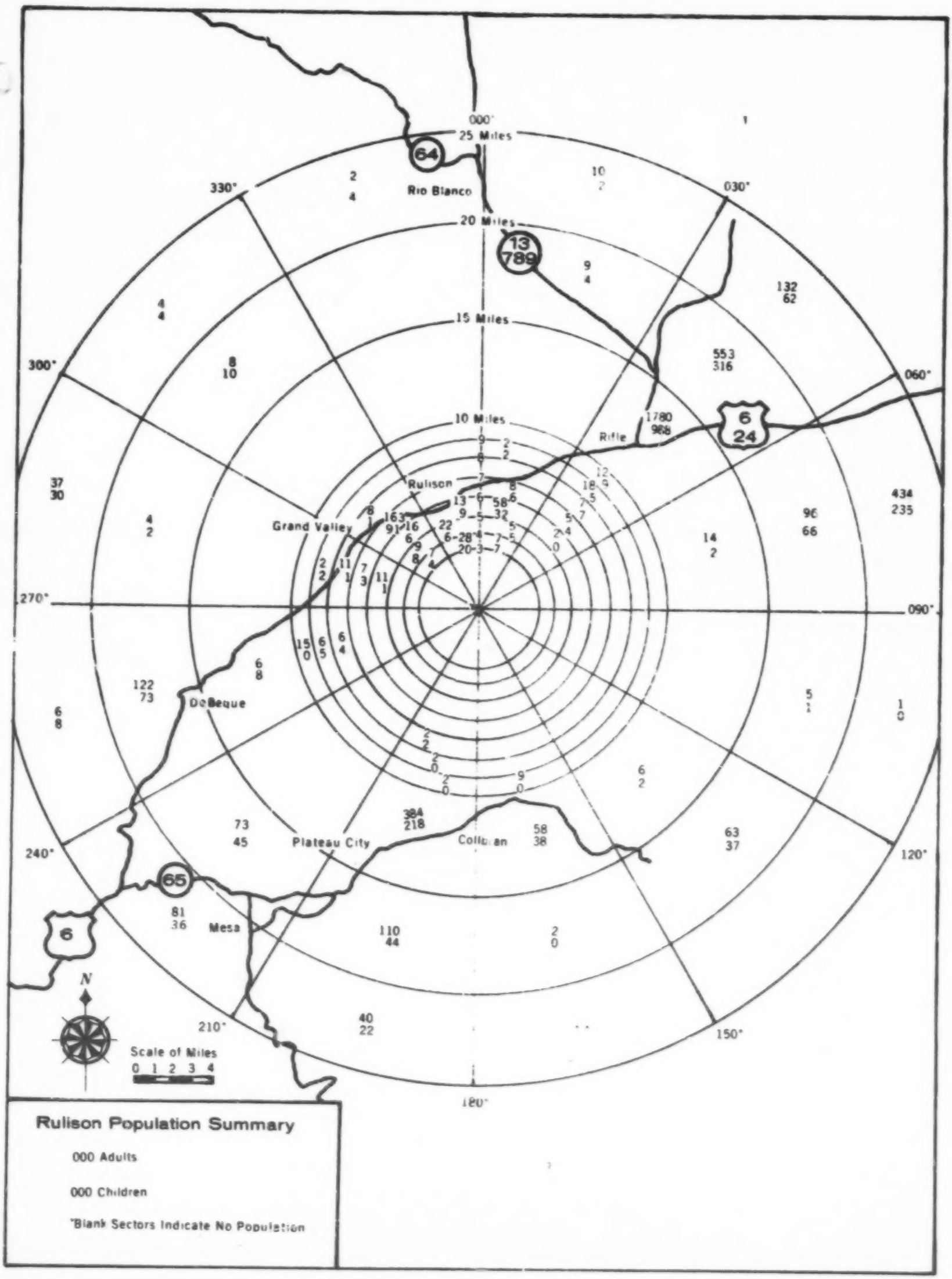

Figure 2. Rulison Population Summary

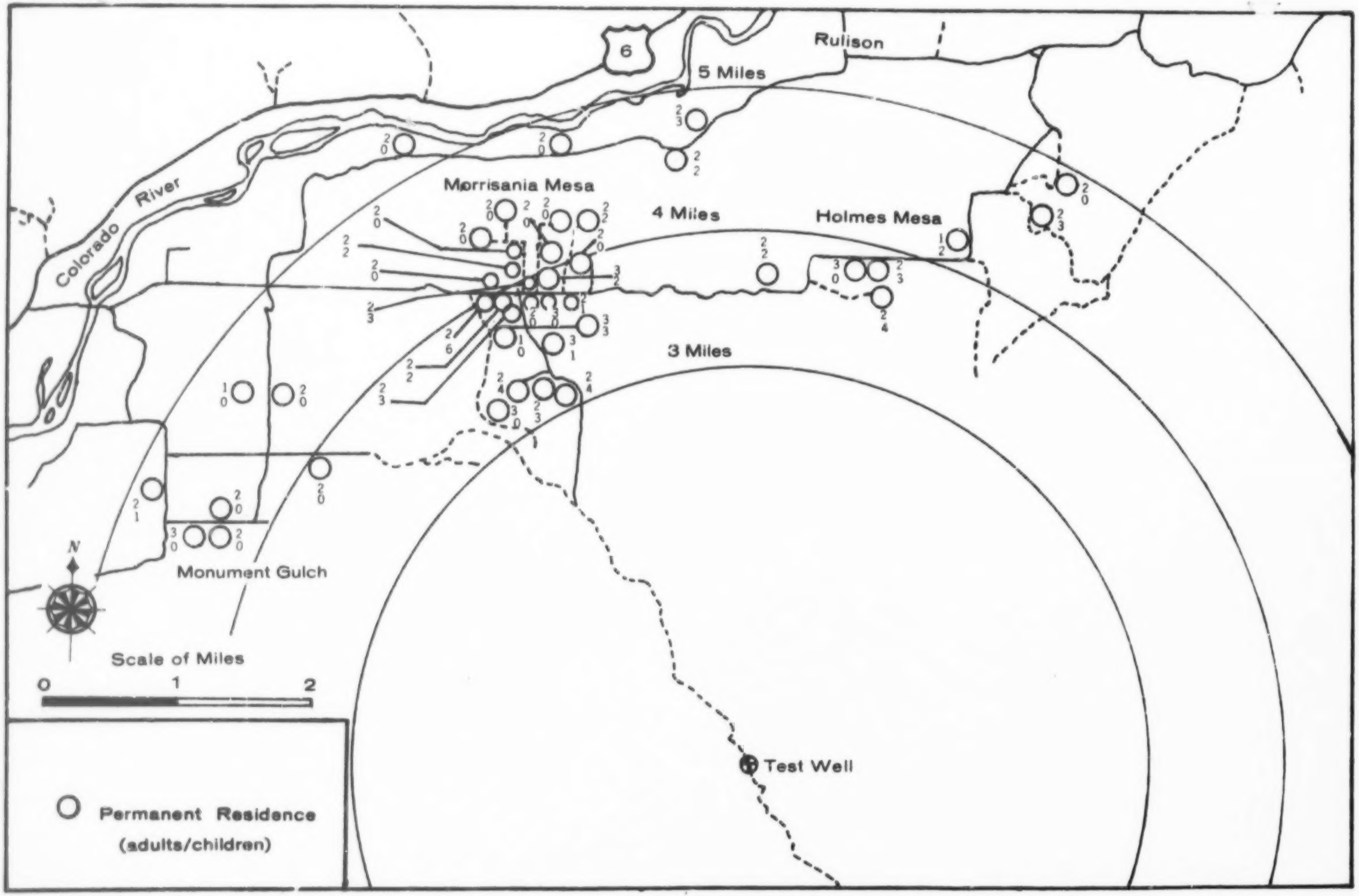

Figure 3. 0—5 Mile Population Distribution

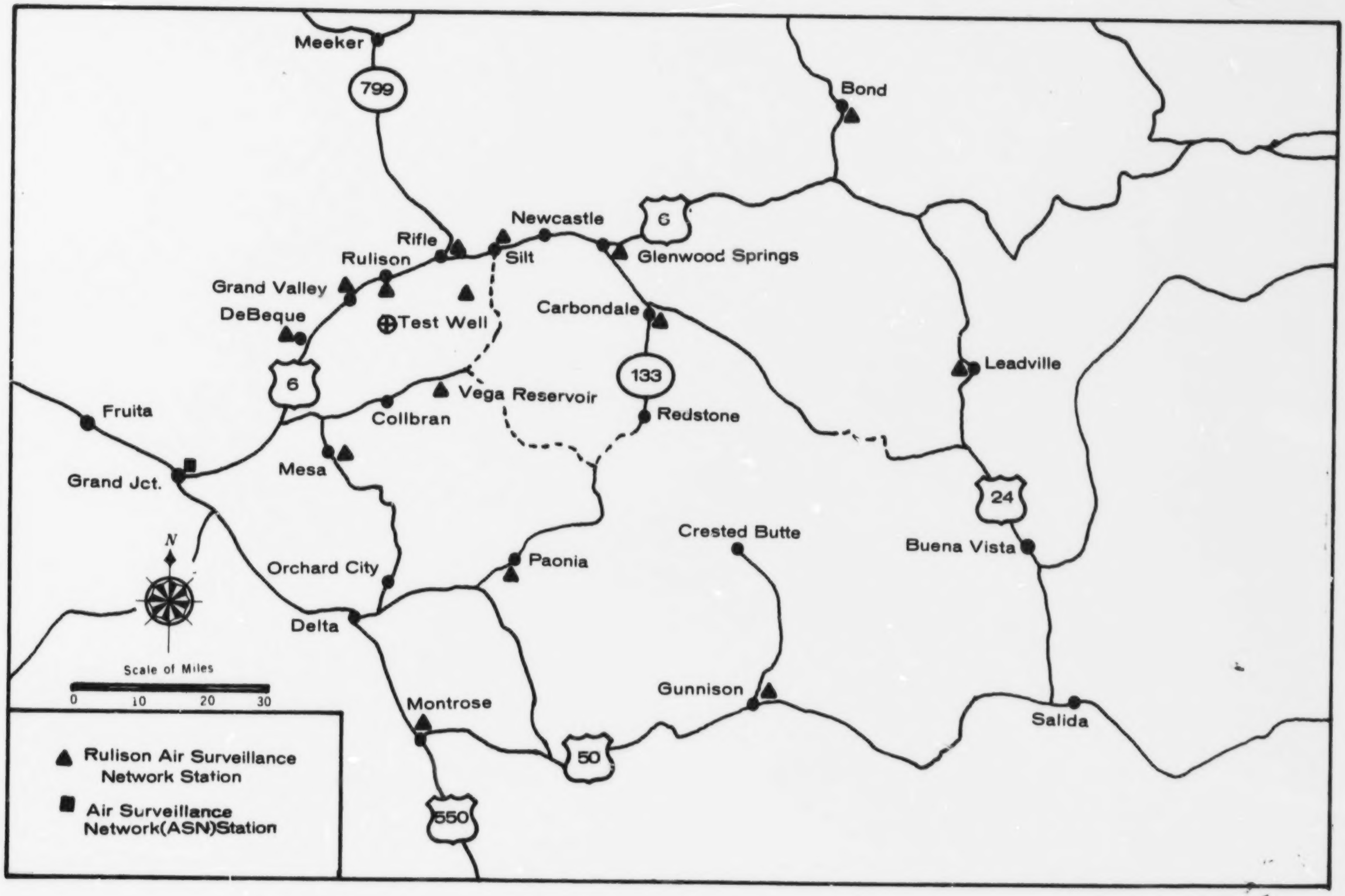

Figure 4. Air Sampling Stations

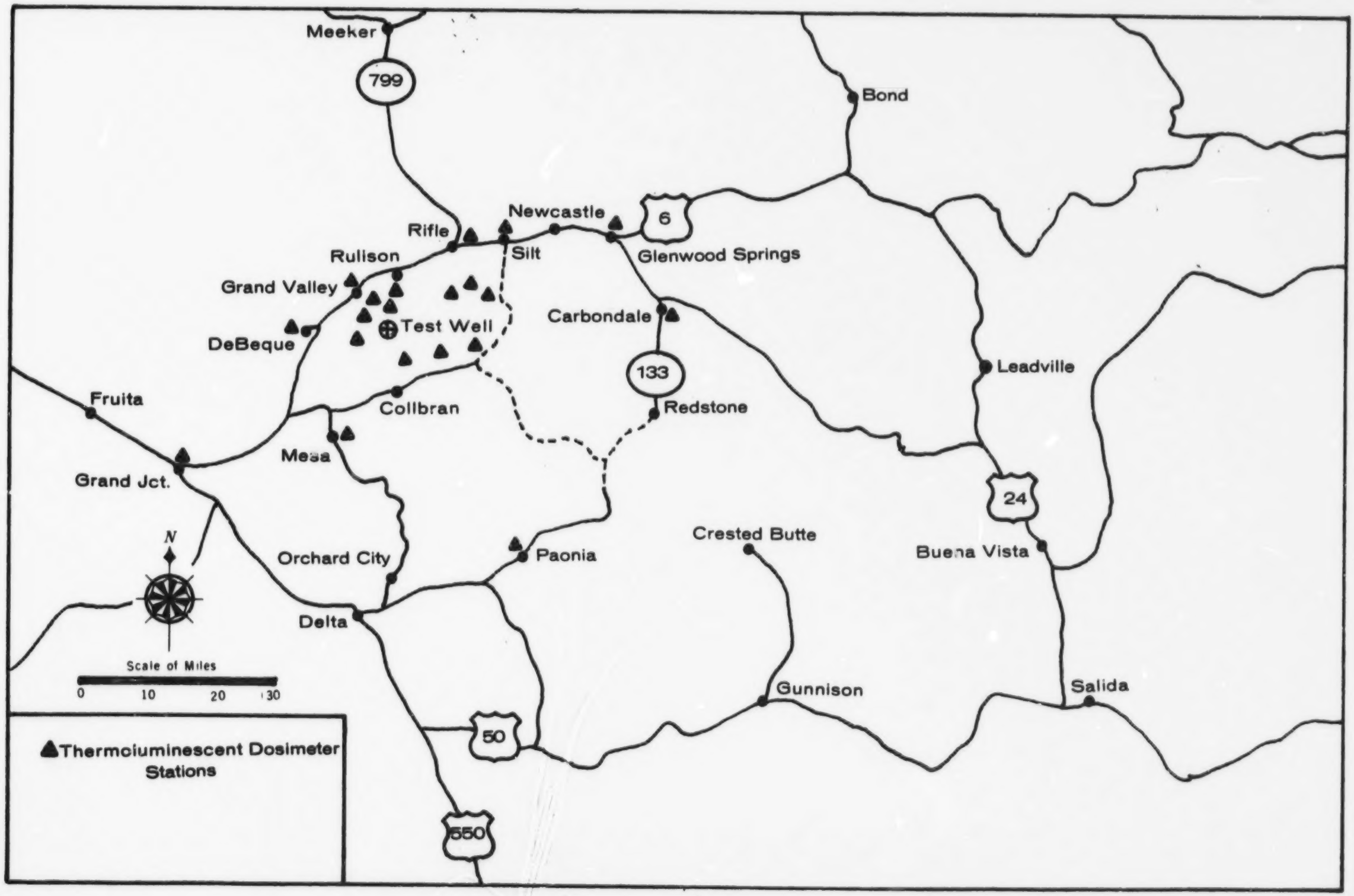

Figure 5. Dosimetry Stations

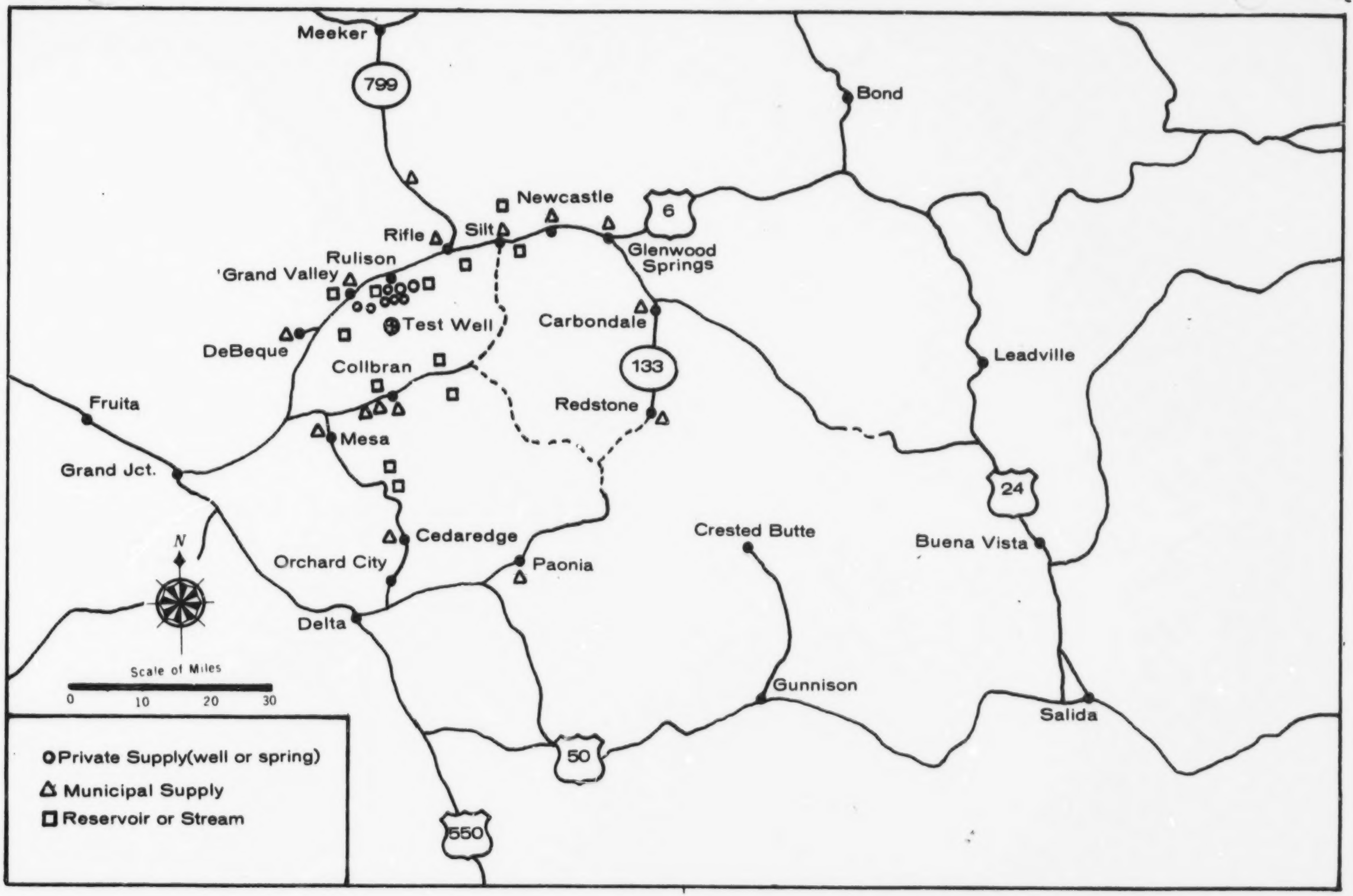

Figure 7. Water Sampling Stations

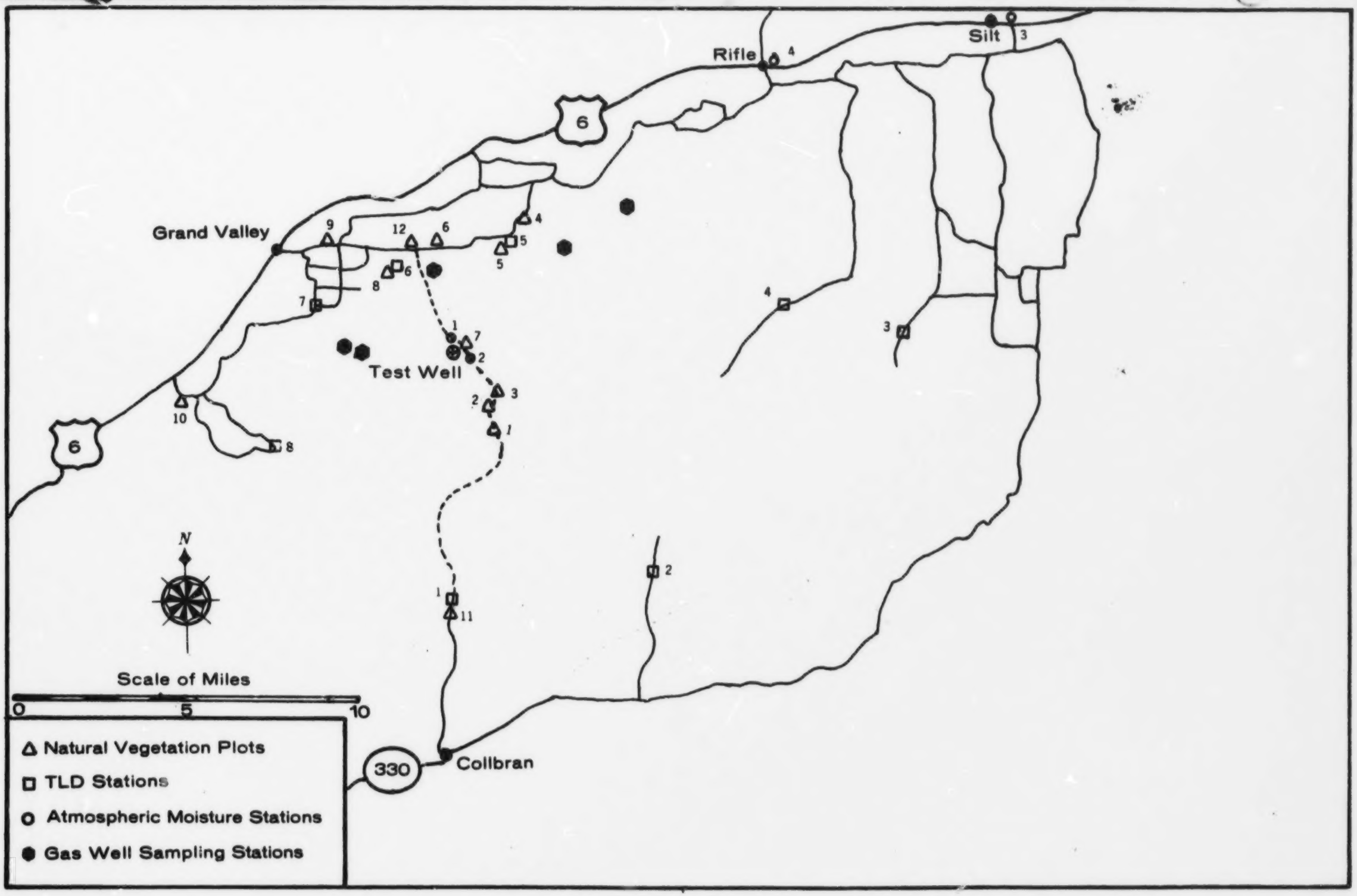

Figure 8. Test Well Vicinity Sampling Stations

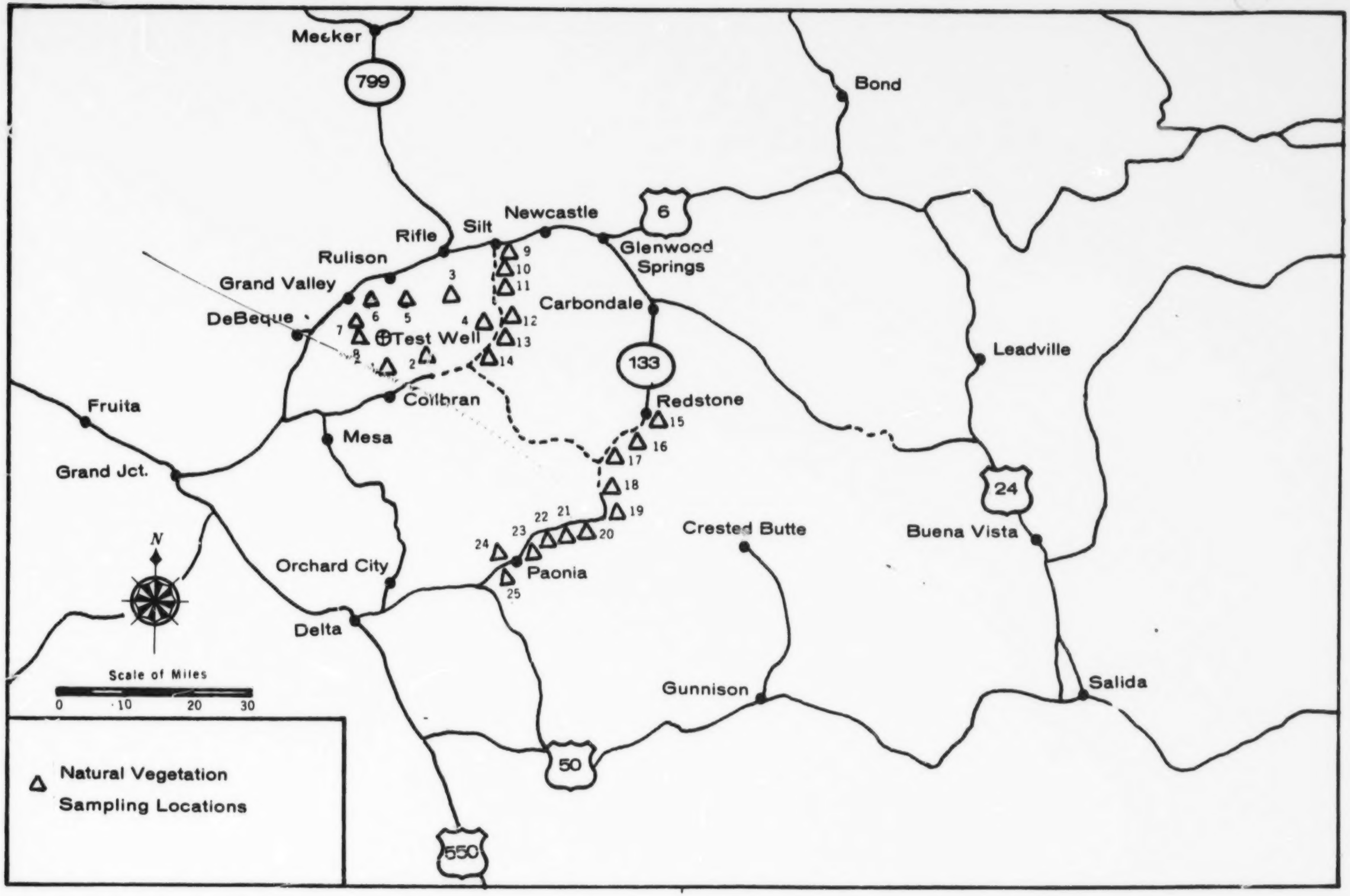

Figure 9. Natural Vegetation Sampling Locations

Table 1. TLD Network results.

Station location[a]	Average Exposure (mR/day)	
	Pre-event	Post-event
1 (182°, 7 mi)	0.35	Lost[b]
2 (136°, 8 mi)	0.30	0.27
3 (90°, 13 mi)	0.21	0.33
4 (80°, 10 mi)	0.23	0.30
5 (20°, 4 mi)	0.27	0.24
6 (330°, 3 mi)	0.25	0.25
7 (295°, 5 mi)	0.24	0.30
8 (245°, 6 mi)	0.25	0.26
Collbran	0.23	0.29
Paonia	0.13	0.27
Mesa	0.19	0.26
Glenwood Springs	0.23	Lost
Carbondale	0.22	0.37
Grand Valley	0.18	0.24
Rifle	0.24	0.28
Silt	0.24	0.34
Rulison	0.24	0.40
Grand Junction	0.25	0.28
Silt Mesa	0.25	0.27
DeBeque	0.24	0.32

[a] Azimuth and distance from the test well given for stations 1 through 8. Station numbers correspond to locations shown in Figure 8.

[b] "Lost" indicates TLD's were not retrieved due to vandalism or station inaccessibility at the end of the exposure period.

Table 2. Gross beta results - Rulison Air Surveillance Network

Station location	Number of samples		Number of Samples above MDA[a]		Average activity above MDA[b] (pCi/m^3)					
	Pre-shot	Post-shot	Pre-shot	Post-shot	Pre-shot			Post-shot		
					Ave.	Max.	Min.	Ave.	Max.	Min.
Mesa	30	21	20	9	0.3	0.6	0.2	0.3	0.8	0.2
Gunnison	30	16	17	5	0.3	0.6	0.2	0.5	0.8	0.2
Montrose	29	16	15	7	0.4	0.7	0.2	0.3	0.5	0.2
Paonia	29	14	16	10	0.4	0.6	0.2	0.3	1.1	0.1
Vega Reservoir	29	18	16	4	0.4	1.5	0.2	0.3	0.5	0.2
Grand Valley	30	21	22	16	0.4	0.7	0.2	0.2	0.4	0.1
Rifle	28	21	18	15	0.4	0.6	0.2	0.2	0.6	0.1
Rulison	30	22	22	19	0.4	0.8	0.2	0.3	0.8	0.2
Silt	30	21	25	15	0.4	0.8	0.2	0.3	1.0	0.2
Bond	9	16	5	7	0.4	0.5	0.2	0.4	0.6	0.2
Leadville	30	15	18	8	0.3	0.6	0.2	0.4	0.9	0.2
Glenwood Springs	23	9	9	5	0.4	0.6	0.2	0.3	0.7	0.1
Carbondale	30	15	19	7	0.4	0.8	0.2	0.4	1.0	0.2
Silt Mesa	30	15	21	8	0.3	0.6	0.2	0.3	0.8	0.1
DeBeque	24	20	18	14	0.3	0.6	0.1	0.3	0.6	0.2

[a] MDA; Minimum detectable activity: Net activity where the 95% confidence level error is less than 25% of the net activity. (Average MDA approximately 0.13 pCi/m^3).

[b] Average, maximum and minimum values are for those samples with activity above the MDA. Samples with results below the MDA were omitted.

Table 3. Tritium in atmospheric moisture samples.

Sampling location (azimuth, distance)[a]	Sample Type	Collection[b] Date/Time	Air Volume (liters)	Water Volume (ml)	Tritium concentration (pCi/ml H_2O)	Tritium concentration (pCi/m^3 Air)[c]
Aircraft over test well 11,500' MSL	Molecular Sieve	9/2/69 1320	4800	28	0.74	4
Station No. 1 (324°, 2.5 mi)	Freeze-out	9/1/69 1030	732	2.9	< 2	< 8
Station No. 1 (324°, 2.5 mi)	Molecular Sieve	9/1/69 1030	1700	3.1	< 2	< 4
Station No. 1 (324°, 2.5 mi)	Freeze-out	9/1/69 2140	810	2.5	< 2	< 7
Station No. 2 (164°, 0.5 mi)	Freeze-out	9/1/69 1250	771	2.1	< 3	< 8
Station No. 2 (164°, 0.5 mi)	Molecular Sieve	9/1/69 1250	1440	0.7	< 9	< 5
Station No. 3 (57°, 19 mi)	Freeze-out	9/1/69 1600	1244	3.0	< 2	< 5
Station No. 4 (44°, 13 mi)	Freeze-out	9/1/69 1815	694	2.0	< 3	< 10

[a] Azimuth and distance from the test well. Station numbers correspond to locations shown in Figure 9.

[b] Sampling periods were approximately one hour.

[c] Ambient conditions.

Table 4. Water sampling results.

Type of Activity	Number of Samples		Number of samples above MDA[a]		Concentration above MDA[b] (pCi/l)					
					Pre-shot			Post-shot		
	Pre-shot	Post-shot	Pre-shot	Post-shot	Avg	Max	Min	Avg	Max	Min
Gross beta	86	37	69	33	15	200	2	7	19	2
Gross alpha	86	37	49	23	13	123	2	5	17	2
Tritium	23	14	15	8	940	1500	560	730	920	440

[a] MDA; Minimum detectable activity, as given in Appendix A.

[b] Average, maximum and minimum values are for those samples with activity above the MDA. Samples with results below the MDA were omitted.

Table 5. Milk sampling results.

Nuclide	Number of Samples		Number of samples above MDA[a]		Average activity above MDA[b] (pCi/l)					
					Pre-shot			Post-shot		
	Pre-shot	Post-shot	Pre-shot	Post-shot	Avg	Max	Min	Avg	Max	Min
^{131}I	33	26	0	0	--	--	--	--	--	--
^{137}Cs	33	26	6	8	15	20	10	12	20	10
^{89}Sr	32	15	12	6	7	9	5	7	9	5
^{90}Sr	32	15	31	15	6	11	2	6	11	2
^{3}H	4	7	4	6	990	1400	540	700	1400	410

[a] MDA; Minimum detectable activity, as given in Appendix A.

[b] Average, maximum and minimum values are for those samples with activity above the MDA. Samples with results below the MDA were omitted.

Table 6. Milk cow feed results.

Location	Type of Feed	^{95}Zr (pCi/kg wet weight)
Collbran, Colorado		
C. W. Young Dairy	Native grass	94
Wm. C. Earley Ranch	Native grass	390
Arthur Linn Ranch	Native grass	260
Clifford Hill Ranch	Native grass	480
Glenwood Springs, Colo.		
Rock N Pines Dairy	Legume hay	270
Mesa, Colorado		
Rupert W. Wasson Dairy	Native grass	520
Molina, Colorado		
Glenn Taylor Dairy	Native hay	230
Mrs. Geo. Currier Ranch	Native grass	380
Rifle, Colorado		
Alex C. Urquhart Dairy	Legume hay	290
Rulison, Colorado		
Donald Burtard Ranch	Pasture grass	130
Felix Sefcovic Ranch	Pasture grass	440
Billie Lee Smith Ranch	Native hay	880
Silt, Colorado		
Rufus Raley Ranch	Native hay	320
Don Jacket Ranch	Native hay	160
Emil Lopez Ranch	Native grass	370

Table 7. Tritium in natural vegetation (plot samples).

Plot location[a]	Type of Vegetation	Mean ^{3}H Concentration[b] (pCi/l)	(pCi/kg wet weight)
Plot No. 1	Subalpine Fir	1780 ± 520	850 ± 520
2	Subalpine Fir	1560 ± 740	910 ± 690
3	Douglas Fir	1680 ± 1280	1610 ± 1680
4	Big Sagebrush	1140 ± 600	1130 ± 750
5	Alfalfa	1200 ± 490	1810 ± 750
6	Big Sagebrush	1240 ± 720	1280 ± 840
7	Big Sagebrush	2700 ± 2950	1520 ± 1490
8	Alfalfa	1190 ± 460	920 ± 330
9	Big Sagebrush	1390 ± 650	1610 ± 730
10	Big Sagebrush	2300 ± 1700	2280 ± 1190
11	Big Sagebrush	1300 ± 480	880 ± 540
Plot Nos. 8 and 12	Fruit[c]	1430 ± 700	7600 ± 5250

[a] Plot numbers correspond to locations shown in Figure 8.

[b] Mean concentration of 27 samples from each plot(except for plot No. 12).

[c] Apples, pears, and apricots from vicinity of plot No. 8, and cherries from plot No. 12. All fruits combined for analysis.

Table 8. Natural vegetation results (station samples).

Station Location[a]	Type of Vegetation	^{95}Zr (pCi/kg wet weight)
Station No. 1	Sagebrush	140
" " 2	Sagebrush	81
" " 3	Sagebrush	74
" " 4	Sagebrush	290
" " 5	Sagebrush	450
" " 6	Sagebrush	360
" " 7	Sagebrush	620
" " 8	Sagebrush	70
" " 9	Native grass	<MDA[b]
" " 10	Native grass	710
" " 11	Native grass	20
" " 12	Native grass	630
" " 13	Native grass	950
" " 14	Native grass	590
" " 15	Native grass	1100
" " 16	Native grass	<MDA
" " 17	Sagebrush	1500
" " 18	Native grass	2300
" " 19	Native grass	1800
" " 20	Sagebrush	790
" " 21	Native grass	720
" " 22	Native grass	950
" " 23	Sagebrush	16
" " 24	Native grass	330
" " 25	Native grass	<MDA

[a] Station numbers correspond to locations shown in Figure 9.

[b] MDA - less than the minimum detectable activity for the system utilized.

Table 9. Strontium-89 and -90 in wildlife.

Sample description		^{89}Sr	^{90}Sr
Fawn, road killed 8/27/69, 3 miles south of Mesa, Colorado.			
	Bone hock (pCi/kg)	1563	881
	(pCi/gm ash)	6.9	3.9
Two year old buck, hunter killed 8/17/69 on Uncompahgre Plateau west of Delta, Colo.			
	Bone hock (pCi/kg)	1633	1725
	(pCi/gm ash)	5.4	5.7
Four year old buck, hunter killed 8/29/69, 21 miles south of Carbondale, Colo.			
	Bone hock (pCi/kg)	1288	2698
	(pCi/gm ash)	3.7	7.7
Five year old buck, hunter killed 8/19/69 near Hubbard Creek.			
	Bone hock (pCi/kg)	1138	2131
	(pCi/gm ash)	3.4	6.4
Yearling buck, hunter killed 8/16/69 in the Dike Creek Hightower area.			
	Bone hock (pCi/kg)	3366	2020
	(pCi/gm ash)	10	6.0

Table 10. Natural gas results.

Well location (azimuth, distance)[a]	Date Collected	^{222}Rn	^{3}H	^{14}C	^{133}Xe	^{85}Kr
		(pCi/l)				
Section 14 (331°, 2.7 mi)	5/1/69	1.1[b]	ND	ND	ND	ND
Federal 28-0 (272°, 2.8 mi)	5/1/69	36	ND	ND	ND	ND
	9/6/69	29	ND	ND	ND	ND
	9/12/69	29	ND	ND	ND	ND
Federal A-29-95 (271°, 3.7 mi)	9/6/69	45	ND	ND	ND	ND
	9/6/69	26	ND	ND	ND	ND
Section 8 (34°, 4.1 mi)	9/12/69	1.1[b]	No chemistry			
Federal 3-94 (35°, 6.2 mi)	5/1/69	34	ND	ND	ND	ND
	9/6/69	27	ND	ND	ND	ND

[a] Azimuth and distance from test well. Well locations shown in Figure 8.

[b] A non-producing well, and the sample collected was not representative of formation gas.

ND - No activity above a minimum detectable activity(see Appendix A).

APPENDIX A - Analytical Procedures - Technical Services - SWRHL

Sample, type	Analysis	Instrumentation	Count Length	Analytical Procedures	Minimum Detectable Activity	Notes
Air filter						
a) Glass-fiber	Beta	Low background Wide beta I	2 min.	Gross activity at time of count. Repeated counts for extrapolation to estimate activity at end of collection time.	Net counts exceed 4 times 2-sigma counting error.	
	Gamma	Gamma spectrometer	10 min.	8x8 matrix solution. Selected isotopes specified in equations' solution.	0.1 pCi/m^3 single isotope.	50-100 pCi total in sample/isotope.
b) Charcoal	Gamma	Gamma spectrometer	10 min.	Gross count with warning limit set at 300 CFM above background over 0-2 MeV energy range. Isotopic analysis by 8x8 matrix solution.	0.1 pCi/m^3 single isotope.	50-100 pCi total in sample/isotope.
Milk	Gamma	Gamma spectrometer	40 min.	Isotopic analysis by 8x8 matrix solution.	10 pCi/l ^{131}I 10 pCi/l ^{137}Cs 10 pCi/l ^{140}Ba-La	If masking occurs (presence of other isotopes) detectable limit will vary.
	^{89}Sr	Low background Wide beta II	50 min.	Chemical separation by ion-exchange method. Separated sample counted successively; activity calculated by simultaneous equation solution.	5 pCi/l	Strontium-89 and -90 analysis dictated by presence of ^{131}I, or ^{140}Ba-La. (>20 pCi/l).
	^{90}Sr	Low background Wide beta II	50 min.		2 pCi/l	
Water	Gamma	Gamma spectrometer	40 min.	Isotopic analysis by 8x8 matrix solution.	10 pCi/l	
	Alpha	Wide beta II	50 min.	Sample dried, gross activity calculated.	2 pCi/l	
	Beta	Wide beta II	50 min.		2 pCi/l	
	^{89}Sr	Wide beta II	50 min.	Chemical separation by ion-exchange.	5 pCi/l	Strontium-89 and -90 analysis dictated by presence of ^{131}I or ^{140}Ba-La. (>20 pCi/l).
	^{90}Sr	Wide beta II	50 min.	Separated sample counted successively; activity calculated by solution of simultaneous equations.	2 pCi/l	
	^{3}H	Liquid scintillator	100 min.	Sample prepared by distillation. Counted in liquid scintillation counter.	400 pCi/l	
Feed	Gamma	Gamma spectrometer	10-20 min.	Isotopic analysis by 8x8 matrix solution.	50 pCi/kgm	

APPENDIX A (continued)

Sample, type	Analysis	Instrumentation	Count Length	Analytical Procedures	Minimum Detectable Activity	Notes
Vegetation	Gamma	Gamma spectrometer	10 min.	Gross activity calculated. Qualitative analysis.		Quantitation only within order of magnitude for select isotopes.
Air						
a) Grab	Xenon and krypton Beta	Glass envelope Geiger counter	30 min.	Inert gases separated from air sample and beta counted. Xenon and krypton activity concentration is calculated.	100 pCi total sample	0.3 m^3 usual sample size.
b) Molecular sieve 1. Ambient	^3H & ^{14}C	Liquid scintillation counter	100 min.	Water and CO_2 removed from sieve and collected. Water analyzed for ^3H and CO_2 for ^{14}C by liquid scintillation counting.	^3H 0.4 pCi/ml[a] H_2O ^{14}C 6 pCi/m^3 air	Based on a minimum of 5 mls moisture.
2. Cryogenic	^3H & ^{14}C	Liquid scintillation counter	100 min.	Water, CO_2 and noble gases removed from sieve, separated and collected. Water analyzed for ^3H and CO_2 for ^{14}C by liquid scintillation.	^3H 0.4 pCi/ml[a] H_2O ^{14}C 6 pCi/m^3 air	1.5-4.0 m^3 usual sample size.
	Xenon and krypton	Glass envelope Geiger counter		Xenon and krypton fractions beta counted in glass envelope Geiger counter.	Xe & Kr 100 pCi total sample.	
c) Freeze-out	^3H	Liquid scintillation counter	100 min.	Air passed over cold trap to freeze out moisture. Water analyzed for tritium.	^3H 0.4 pCi/ml[a] H_2O	3-6 liters per min. sampling rate. Sample size varies.
Natural gas	Rn	Rn-alpha scintillation counting	60 min.	Rn-direct transfer to alpha scintillation cell and counting.	Rn-0.04 pCi/l	100 ml alpha scintillation cell.
	^3H & ^{14}C	Liquid scintillation counting	100 min.	Gas is combusted and noble gases, water, and CO_2 are separated.	20 pCi/l(^{14}C) 1 pCi/l(^3H)	About 4-1 burned.
	Xe & Kr	Glass envelope Geiger counter	30 min.		100 pCi total sample 100 pCi total sample	About 12-1 burned.

Descriptions can be found in Document NV-28, USAEC Publication, Revised 1968.
Detailed procedures are presented "SWRHL Analytical Procedures Manual," SWRHL.
Instrumentation Description: a) Gamma spectrometer; 4"x4" NaI (Tl) detector, 200 channels calibrated at 10 key (channel detector enclosed in a steel box with 6" thick walls, with lead, cadmium and copper lining.)
b) Wide beta I, pure methane gas flow, 4" hemispherical detector with anti-coincidence guard ring and automatic sample changer with 60-sample capacity.
c) Wide beta II, pure methane gas flow, 2" hemispherical detector with anti-coincidence guard ring and automatic sample changer with 80-sample capacity.
d) Liquid scintillation counter. Ambient temperature.
NOTE: Detectable limit for ^{14}C in air (Air b) based on assumption of 0.03% CO_2 in air.
Reference a: $1\text{-}8 \times 10^3$ pCi/m^3 air depending on relative humidity in anticipated range.

APPENDIX B - Water sampling results.

Location	Source	Date Collected	Gross alpha pCi/l	Gross beta pCi/l	^3H pCi/l
Carbondale, Colorado					
Phillips 66 Station	Tap	04/21/69	<2	<2	
Phillips 66 Station	Tap	08/30/69	<2	<2	
Phillips 66 Station	Tap	11/05/69	<2	<2	
Cedaredge, Colorado					
Conoco Station	Tap	04/21/69	<2	8	
Conoco Station	Tap	08/26/69	<2	2	
Conoco Station	Tap	11/04/69	<2	2	
Collbran, Colorado					
Buzzard Creek	Stream	04/22/69	13	24	1200
Buzzard Creek	Stream	08/26/69	2	5	
Buzzard Creek	Stream	11/05/69	3	10	880
D Bar J Cafe	Spring	04/22/69	5	10	
D Bar J Cafe	Spring	08/27/69	6	6	
D Bar J Cafe	Spring	11/05/69	3	8	
Arthur Linn Ranch	Spring	08/27/69	7	5	1100
Plateau Creek	Stream	04/22/69	6	11	
Plateau Creek	Stream	08/26/69	6	11	
Plateau Creek	Stream	11/05/69	4	8	
Vega Reservoir Resort	Rsvr	04/22/69	3	8	
Vega Reservoir Resort	Rsvr	08/26/69	3	10	
Vega Reservoir Resort	Rsvr	09/01/69	<2	2	
Vega Reservoir Resort	Rsvr	11/05/69	<2	7	
Wallace Deer Camp	Stream	09/03/69	<2	3	590
Wm. H. Wallace Ranch	Spring	11/05/69	2	4	600
DeBeque, Colorado					
Sinclair Station	Tap	04/21/69	3	6	
Sinclair Station	Tap	08/29/69	2	6	
Sinclair Station	Tap	11/04/69	<2	8	
Glenwood Springs, Colo.					
Phillips 66 Station	Tap	04/21/69	<2	2	
Phillips 66 Station	Tap	08/30/69	2	<2	
Phillips 66 Station	Tap	11/05/69	<2	2	
Grand Mesa, Colorado					
Beaver Lake	Lake	04/21/69	<2	37	
Beaver Lake	Lake	08/26/69	<2	2	
Beaver Lake	Lake	11/04/69	<2	<2	
Jumbo Lake	Lake	04/21/69	<2	60	
Jumbo Lake	Lake	08/26/69	<2	4	
Jumbo Lake	Lake	11/04/69	4	4	

APPENDIX B (continued)

Location	Source	Date Collected	Gross alpha pCi/l	Gross beta pCi/l	^3H pCi/l
Grand Valley, Colorado					
H. W. Arnett Ranch	Tap	04/23/69	4	< 2	<400
Battlement Creek	Stream	04/22/69	5	9	950
Battlement Creek	Stream	07/21/69	< 2	2	1500
Battlement Creek	Stream	08/28/69	< 2	4	
Battlement Creek	Stream	11/04/69	< 2	5	740
Battlement Cr. (above test well)	Stream	07/21/69	< 2	3	1300
Battlement Cr. (above test well)	Stream	11/17/69	3	4	830
Battlement Reservoir	Rsvr	07/21/69	< 2	12	1200
Dan Duplice Ranch	Well	04/22/69	8	4	< 400
Dan Duplice Ranch	Well	08/28/69	4	5	
Dan Duplice Ranch	Well	11/04/69	< 2	8	< 400
Edward Forshee Ranch	Spring	04/22/69	30	7	< 400
Edward Forshee Ranch	Spring	08/28/69	6	3	
Edward Forshee Ranch	Spring	11/04/69	5	19	< 400
Parachute Creek	Stream	04/21/69	73	110	
Parachute Creek	Stream	08/28/69	5	10	
Parachute Creek	Stream	11/04/69	2	8	
Sinclair Service Station	Tap	04/21/69	7	< 2	630
Sinclair Service Station	Tap	08/28/69	6	3	
Sinclair Service Station	Tap	11/04/69	6	3	< 400
Test Well	Well	08/25/69	< 2	6	800
Test Well	Well	11/17/69	2	6	920
Wallace Creek	Stream	04/22/69	6	7	
Wallace Creek	Stream	08/28/69	< 2	5	
Wallace Creek	Stream	11/04/69	5	10	
Marie Zediker	Spring	04/22/69	11	4	< 400
Marie Zediker	Spring	08/28/69	6	9	
Marie Zediker	Spring	11/04/69	6	15	< 400
Mesa, Colorado					
Post Office	Spring	04/21/69	< 2	2	
Post Office	Spring	08/26/69	5	5	
Post Office	Spring	11/04/69	5	4	
Molina, Colorado					
Mercantile Store	Well	04/21/69	10	7	
Mercantile Store	Well	08/26/69	3	10	
Mercantile Store	Well	11/05/69	6	9	

APPENDIX B (continued)

Location	Source	Date Collected	Gross alpha pCi/l	Gross beta pCi/l	^3H pCi/l
New Castle, Colorado					
Texaco Service Station	Tap	04/21/69	2	< 2	
Texaco Service Station	Tap	08/30/69	2	< 2	
Texaco Service Station	Tap	11/05/69	2	4	
Paonia, Colorado					
Conoco Station	Tap	04/21/69	<2	< 2	
Conoco Station	Tap	08/26/69	<2	< 2	
Conoco Station	Tap	11/04/69	<2	< 2	
Plateau City, Colorado					
Conoco Station	Well	04/22/69	12	12	
Conoco Station	Well	08/26/69	9	14	
Conoco Station	Well	11/05/69	17	16	
Redstone, Colorado					
Conoco Station	Tap	04/21/69	< 2	5	
Conoco Station	Tap	08/30/69	< 2	< 2	
Conoco Station	Tap	11/05/69	< 2	2	
Rifle, Colorado					
Mamm Creek	Stream	04/22/69	123	200	
Mamm Creek	Stream	08/29/69	6	18	
Mamm Creek	Stream	11/05/69	12	15	
Texaco Station	Tap	04/21/69	3	< 2	
Texaco Station	Tap	08/29/69	< 2	< 2	
Texaco Station	Tap	11/05/69	3	3	
Rio Blanco, Colorado					
Phillips 66 Station	Tap	04/21/69	< 2	2	
Phillips 66 Station	Tap	08/29/69	< 2	< 2	
Phillips 66 Station	Tap	11/05/69	< 2	< 2	
Rulison, Colorado					
Donald Burtard Ranch	Stream	08/31/69	< 2	<2	< 400
Cache Creek	Stream	04/22/69	< 2	8	600
Cache Creek	Stream	08/28/69	< 2	6	
Cache Creek	Stream	11/04/69	< 2	5	440
Eames Orchards	Spring	04/22/69	< 2	2	1100
Eames Orchards	Spring	08/20/69	< 2	4	560
Eames Orchards	Spring	08/29/69	< 2	5	
Eames Orchards	Spring	11/05/69	<2	4	710
Lee L. Hayward Ranch	Well	04/22/69	19	< 2	< 400
Lee L. Hayward Ranch	Well	08/28/69	7	4	
Lee L. Hayward Ranch	Well	11/04/69	10	7	<400

APPENDIX B (continued)

Location	Source	Date Collected	Gross alpha pCi/l	Gross beta pCi/l	^{3}H pCi/l
Rulison, Colorado(continued)					
Walt Lemen Farm	Well	08/28/69	9	8	
Ernest R. Schwab	Well	04/22/69	2	5	560
Ernest R. Schwab	Well	08/29/69	2	3	
Billie Lee Smith Ranch	Well	04/22/69	13	4	<400
Billie Lee Smith Ranch	Well	08/28/69	<2	3	750
Billie Lee Smith Ranch	Well	11/04/69	2	5	<400
Felix S. Sefcovic Ranch	Well	04/22/69	<2	< 2	<400
Felix S. Sefcovic Ranch	Well	08/28/69	<2	3	
Felix S. Sefcovic Ranch	Well	11/04/69	3	19	750
Felix S. Sefcovic Ranch[a]	Spring	08/28/69	77	141	
Felix S. Sefcovic Ranch[a]	Spring	08/28/69	<2	< 2	
Silt, Colorado					
Larry Antonelli	Well	05/01/69	5	3	
Harvey Gap Reservoir	Rsvr	04/22/69	7	3	
Harvey Gap Reservoir	Rsvr	08/29/69	5	6	
Harvey Gap Reservoir	Rsvr	11/06/69	<2	5	
Don Jackett Ranch	Well	08/29/69	8	4	1200
Fred Pferdesteller Rn.	Well	09/01/69	19	5	
Sinclair Service Station	Tap	04/21/69	3	3	
Sinclair Service Station	Tap	08/29/69	< 2	5	
Sinclair Service Station	Tap	11/5/69	2	7	
West Divide Creek	Stream	04/22/69	83	72	
West Divide Creek	Stream	08/29/69	5	13	
West Divide Creek	Stream	11/05/69	5	10	

[a] Separate water supplies.

APPENDIX C - Milk sampling results.

Location	Collection Date	Isotopic concentration (pCi/l) ^{131}I	^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
Collbran, Colorado						
Wm C. Earley Ranch	04/23/69	<10	20	9	11	
	08/28/69	<10	<10	8	9	
	09/13/69	<10	<10	9	7	
	11/05/69	<10	20	No chemistry		
Clifford Hill Ranch	04/22/69	<10	<10	<5	7	
	08/26/69	<10	<10	<5	3	
	09/13/69	<10	<10	<5	4	
	11/05/69	<10	<10	No chemistry		
Arthur Linn Ranch	04/23/69	<10	<10	7	11	
	08/27/69	<10	<10	<5	5	1400
	09/13/69	<10	<10	<5	7	660
	11/05/69	<10	10	No chem.		730
C. W. Young Dairy	04/23/69	<10	<10	<5	3	
	08/26/69	<10	<10	9	9	
	09/13/69	<10	<10	<5	7	
	11/05/69	<10	<10	No chemistry		
Glenwood Springs, Colorado						
Rock N Pines Dairy	04/24/69	<10	<10	<5	4	
	08/30/69	<10	10	5	2	
	09/13/69	<10	<10	<5	2	
	11/05/69	<10	<10	No chemistry		
Grand Junction, Colorado						
Clynn's Crescent Graff	08/14/69	<10	<10	<5	8	
Western Colo. Milk Producers (Grand Junction, Fruita, Clifton, Lona, & Mack production areas)	08/14/69	<10	<10	<5	3	
Western Colo. Milk Producers (Collbran, Mesa & Moline production areas)	08/14/69	<10	<10	<5	5	
Mesa, Colorado						
Rupert W. Wasson Dairy	04/22/69	<10	<10	<5	3	
	08/27/69	<10	<10	6	4	
	09/13/69	<10	10	<5	3	
Molina, Colorado						
Mrs. Geo. Currier Ranch	04/22/69	<10	<10	<5	5	
	08/26/69	<10	<10	6	7	
	09/13/69	<10	<10	6	7	1400

APPENDIX C (continued)

Location	Collection Date	Isotopic concentration (pCi/l) ^{131}I	^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
Molina, Colorado(continued)						
Mrs. Geo. Currier Ranch	11/05/69	<10	<10	No chemistry		
Glenn Taylor	04/22/69	<10	<10	<5	5	
	08/26/69	<10	20	5	9	
	09/13/69	<10	10	<5	5	
	11/05/69	<10	10	No chemistry		
Rifle, Colorado						
Alex C. Urquhart Dairy	04/24/69	<10	<10	<5	<2	
	08/29/69	<10	<10	<5	2	
	09/13/69	<10	10	<5	4	
	11/05/69	<10	<10	No chemistry		
Rulison, Colorado						
Donald Burtard Ranch	04/23/69	<10	<10	<5	7	
	08/31/69	<10	<10	6	6	720
	09/13/69	<10	<10	8	5	490
	11/05/69	<100	<100	No chem.		470
Felix Sefcovic Ranch	04/22/69	<10	<10	<5	6	
	08/29/69	<10	20	7	8	
	09/13/69	<10	10	9	11	
	11/05/69	<100	<100	No chemistry		
Billie Lee Smith	04/23/69	<10	<10	<5	6	
	08/28/69	<10	<10	<5	5	540
	09/12/69	<10	<10	<5	4	410
	11/05/69	<10	20	No chem.		<400
Silt, Colorado						
Don Jackett Ranch	04/23/69	<10	<10	<5	4	
	08/29/69	<10	10	<5	8	1300
	09/13/69	<100	<100	5	4	
Emil Lopez Ranch	04/23/69	<10	<10	6	5	
	08/30/69	<10	<10	No chemistry		
	09/13/69	<10	<10	<5	4	
Rufus Raley Ranch	04/23/69	<10	10	<5	5	
	08/29/69	<10	<10	5	8	
	09/13/69	<10	<10	5	6	